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Studies of the insect pest and predator fauna of an orchard in "Bergische Land", and the influence of pesticides on this fauna

by Ingrid Redenz-Rüsch

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A. Introduction

1. Formulation of the problem

The practice of combatting pests by direct control methods has grown enormously in recent years as a result of the sudden developments in the production of pesticides and the equipment engineering branch.

The consumption of agricultural chemicals for pest control (nowadays 120 million DM are spent by West German agriculturists on crop protection products as against 13 million RM in 1939) continues to increase at a steady rate, as does the acreage of land now treated with these products. But a constant increase is also observed in the incidence of plant diseases and occurrence of insect pests (Riehm 1943, Blunck 1944 etc.).

The question, therefore, arises whether and, if so, to what extent the use of present day conventional pesticides is partly responsible for the excessive reproduction of insect species and thus for changes in the biocoenosis, in other words a shift of the biological balance (Kennedy 1953). The increasing number of observations recently made by research workers of certain secondary effects produced by poisons, usually unintentional effects on the insect pest itself (resistance, stimulation etc.) or on its predator (see survey of pertinent literature P. 170), makes it necessary to carry out a critical study of this aspect on the basis of exact investigations.

In order to provide an answer to the main question regarding the effect of pesticides, especially insecticides, on the orchard fauna, the first task was to register the fauna of the biotope itself, and to study, on the one hand, its interannual population movements in normal conditions and to examine, on the other hand, the abnormal population development of the different insects brought about by application of poisons, i. e. to compare the insect population of a treated plot with that of a plot not treated for several years, from the qualitative and the quantitative aspect.

A matter of prime interest was to establish how and at what rate disturbances of the biocoenosis caused by applications of poison, are re-balanced.

The studies were conducted in 1955 and 1956 at the Höfchen Research Station of Farbenfabriken Bayer Aktiengesellschaft, in Bergische Land.

2. Survey of pertinent literature

In this section, a brief survey will be given of the development of pest control in fruit growing, and the shifts in the fruit tree biocoenosis connected with this development. Large-scale application of crop protection products was still unknown in fruit farming in the 19th century, although the effect given by sulphur (since 1821), copper, nicotine, derris, pyrethrum and arsenic was already known. The actual use of crop protection products did not, however, begin until the 20th century. The introduction of regular spray programmes in the twenties soon led to the first changes in the orchard fauna.

It is a known fact that the toxic effect of crop protection products having a wide spectrum of activity, is not restricted solely to the insect pests but also endangers the predators of these pests; thus, these products are capable of initiating far-reaching changes in the biocoenosis. Massee was the first to observe in 1929 that tar oil winter washes are not only ineffective against

Metatetranychus ulmi Koch but in fact promote the reproduction of these spider mites by killing their predators. Blair and Groves (1952) and Speyer (1937) also attribute the mass reproductions of spider mites to the introduction of winter sprays and the eradication of insects predaceous upon the mites.

Loewel and Reich (1952) and Massee (1953) report on unwanted effects of dinitrocresol products on fruit tree red spider mite and its enemies.

Garman and Townsend (1938), Flanders (1943), Cutright (1944), Güthart (1945), Lord (1947 and 1949), Picket (1949), Clancy and Pollard (1952) inter alia, associate mass reproductions of *M. ulmi* Koch with the elimination of natural enemies, due to the use of sulphur-containing pesticides. — The application of sulphur products in Canada for controlling scab in apple plantations (around 1930) led to calamitous scale infestation. *Lepidosaphes ulmi* L., until 1935 a pest of very minor importance in this region, steadily became a major pest. Lord (1947 and 1949) and Picket (1949) attribute the excessive reproduction of the scale to the fact that its predators (Picket lists these as being primarily *Aphytis mytilaspidis* Leb. and *Hemisarcoptes* malus Shim.) were killed by the sulphur products. They proved that sulphur, in every form, had an eradicating effect on the predaceous insects, whereas the scale insects were not affected at all by elementary sulphur, and only slightly by lime-sulphur. Thomson (1935) and Spencer (1939) report on increases in the population of *Lepidosaphes beckii* Newm. in citrus crops following application of sulphur and copper products. Fisher and Griffiths (1950) later produced evidence that the increase of population density is due to eradication of the fungus enemies *Myiophagus sp.* Thaxter and *Hirsutella Besseyi* by these products.

Cox (1935), Collins (1936), Driggers (1936), Jaynes (1947), and Picket (1949) established that the reproduction of *Carpocapsa pomonella* L. is indirectly promoted by eradication of its natural enemies following lead arsenate sprays. An increase of the spider mite population also appears likely following application of lead arsenate sprays, according to Graham and Cory (1947).

The most outstanding changes in the biocoenosis, however, were registered in the 1940's as the usage of crop protection products increased, and especially following the inclusion of dichlorodiphenyl trichloroeathane and FOLIDOL-E 605® in the spray programme.

Numerous papers have been published reporting on the effect of dichlorodiphenyl trichloroethane on spider mites and their predators, to mention only the studies of Steiner and Summerland (1944), DeBach (1946), Newcomer and Dean (1946), Griffiths and Thompson (1947), Metcalf (1948), Lord (1949), DeBach, Flechner and Dietrick (1950), Massee (1951), Clancy and Pollard (1952), Geier and Bagglioni (1952) MacPhee (1953) and Berker (1955). All these authors attribute the mass reproductions of spider mites following DDT sprays to the eradication of insects predaceous upon the mites. — Speyer (1937), Baker and Porter (1945), Missiroli (1947), Yothers (1947), Newcomer and Dean (1953) and Massee (1954) report on increased infestation by woolly aphis in apple orchards following application of dichlorodiphenyl trichloroethane. — Similar observations were made by Griffiths and Thompson (1947), Woglum (1947), Clancy and Pollard (1948), Osborn and Mathis (1948), Asquith (1949), DeBach (1951),

Doutt (1951) in respect of scale insects. — Dutch and American authors report on a stimulating effect of dichlorodiphenyl trichloroethane on spider mites (Davis, 1952; Hueck, 1952 and 1953). Reference is made to a stimulating effect on the eggs of spider mites, although it is not established whether this is a case of a direct influence on the mites or rathermore an indirect effect exerted via the plant hosts. A large number of papers have been published on the spectrum of activity of FOLIDOL-E 605 and METASYSTOX® — the insecticides chiefly applied in the tests at Höfchen — in fruit growing, although only few exact indications have so been provided concerning an indirect stimulating effect of these products on pests, showing whether such effect is brought about by elimination of predators, by improvement of nutritional conditions or by other factors.

Bartlett and Ewart (1951) and Elmer, Ewart and Carman (1951) attribute the increase in numbers of *Coccus hesperidum* L. on citrus fruits following application of FOLIDOL-E 605, to decimation of *Metaphycus luteolus* C. and other enemies. Observations showed that the predator fauna had still not been restored even after 6 weeks in some cases and in fact after periods of up to 3 months in others. In contradistinction, Hepburn and Bishop (1951) point out that although beneficial insects were killed by FOLIDOL-E 605 in their tests, a population of desired predatory insects had grown up again already two to three weeks after application of the poison. These authors primarily mention *Exochomus flavipes* Thunbg. and *Aphytis chrysomphali* Mercet. as insects predaceous on these pests. Observations carried out by Clark (1953) show that phosphoric esters, too, are capable of causing a big reproduction of spider mites. This author, however, does not attribute the increased infestation solely to eradication of natural enemies by the insecticide, but rathermore to the physiological state of the fruit trees or to other factors still unknown. Numerous research workers like Mathys (1954 and 1955), Steiner (1955), Günthart (1956), Zweigelt (1956), van den Bosch (1956), Collyer and Groves (1956) refer in their papers to severe decimation or complete eradication of spider mite predators by FOLIDOL-E 605. — Studies conducted by Wiesmann, Gasser and Grob (1951) revealed that FOLIDOL-E 605 kills other beneficial insects besides spider mite predators. These authors provide exact information on the influence of phosphoric esters on the insect fauna of a medium-sized apple tree (in midsummer), according to which 54 % of the killed insects were beneficial species, 22 % were pests and 24 % were indifferent species. Special mention is made of the high mortality among *Coccinellidae*, *Syrphidae* and *Chrysopidae*, the major enemies of aphids. — Ripper, Greenslade and Hartley (1950) report on aphis tests with FOLIDOL-E 605. A reoccurrence of aphis infestation was observed already 10 to 14 days after the treatment; it is stated that eradication of natural enemies accounted for this. It can, however, be argued in contradiction to this assertion that renewed infestation is largely the natural outcome of reproduction potential and ability of the insects to fly.

A stimulating action or a fertilizing effect of FOLIDOL-E 605 was not established by Frohberger (1949) in his studies. Wolfenbarger (1948) and Zattler and Linke (1950), on the other hand, believe the product has a nutritional value. The latter authors proved, for example, that FOLIDOL-E 605 sprays brought significant yield increases of treated hops.

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Furthermore, the development was observed of spider mite strains resistant to FOLIDOL-E 605. Smith (1948) was the first to prove the formation of resistant spider mite populations. Similar observations were made by Graham (1949), Smith and Fulton (1949 and 1951), and Fjelddalen and Daviknes (1952), although only for spider mites in greenhouses. The first resistance of *M. ulmi* Koch was observed in orchards in 1951 (Newcomer and Dean, 1952).

Only few papers have been published dealing with secondary effects of SYSTOX® and METASYSTOX in fruit crop protection. Mathys (1955) reports of increases in the population of fruit tree red spider mite of grape vines following application of SYSTOX products, and attributes this to the complete elimination by SYSTOX of the chief enemies of spider mites, namely members of the predatory *Typhlodromus* genus. — Studies conducted by Ahmed (1954) in cotton plantations prove that SYSTOX and also METASYSTOX are toxic to several enemies of aphids, namely *Syrphidae* and *Coccinellidae* larvae. Adult *Coccinellidae* and *Chrysopa* larvae, on the other hand, were not affected by these products. Similar observations were made by van den Bosch and Reynolds (1956). Ripper (1944) reports that METASYSTOX severely decimates not only *Aphis fabae* Scopoli and *Brevicoryne brassicae* L. but also their natural enemies, namely *Syrphidae, Coccinellidae* larvae and parasites. Renewed aphis infestation was registered here in the test plots three weeks after application of the insecticide.

It is evident from this survey that very many papers have been published on the range of action of different pesticides used in fruit growing. The greater majority of the studies dealt with the effect of the product only on individual pest species and their enemies. Other publications register the mortality of insects in tree crowns following control operations (Wiesmann, Gassner and Grob, 1951 and 1957). The numbers of insects that survived controls have, however, seldom been recorded, and only few comparisons have been made with untreated check plots (Massee, 1947; Collyer, 1952). There are hardly any papers available on quantitative biocoenotic studies in orchards, although such studies are now in progress at various places in the Federal Republic of Germany and also abroad.

B. Fundamentals of the study

1. Natural conditions at test site

The Höfchen Research Centre near Burscheid, is located approximately 200 metres a. s. l. on a range of hills in Bergische Land, some 20 kilometres north-east of Cologne.

The location of the test area and the flora of the surrounding district are illustrated in Fig. 1.

The hilly ridge on which Höfchen is situated, runs from north to south, dropping relatively steeply on the east side into the Eifgen Valley, and only slightly on the west side where it is more like a sloping plain. The Höfchen orchard is bordered by pastures and meadows on the north and south sides, and by oak and hornbeam woods on the west and east peripheries.

The soil comprises of deep loess-clay with greywacke inclusions of Devonian origin.

The climate here is of a Central European, sub-Atlantic character.

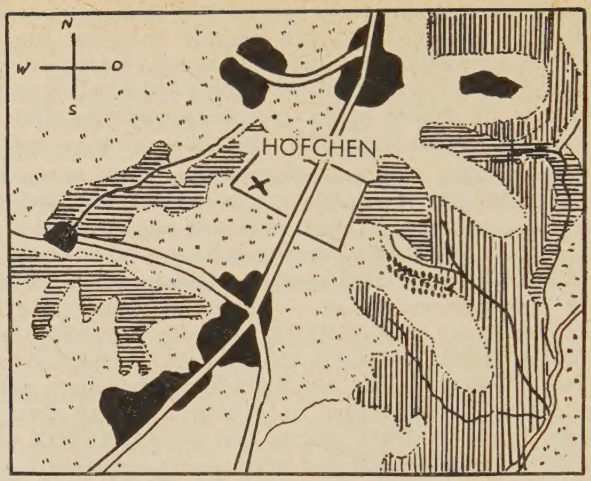


Fig. 1: Location of test site and flora of surrounding district

Table 1: Meteorological data for Höfchen, 1955 and 1956 (monthly means resp. sums)

	Mean daily temp. in °C		Rainfall in mm		Sunshine in hrs.		r. h. in %	
	1955	1956	1955	1956	1955	1956	1955	1956
January	— 0·9	0·9	50·3	72·2	27·0	40·0	82·7	85·6
February	— 1·3	— 8·7	95·6	44·5	62·0	110·3	79·2	79·2
March	0·8	5·0	32·1	23·8	162·0	137·3	78·2	70·5
April	8·1	5·2	32·1	43·0	172·5	125·3	70·2	72·6
May	10·0	13·2	64·2	62·4	186·0	209·4	71·3	66·2
June	15·2	11·9	66·2	192·9	238·7	96·4	70·3	81·7
July	16·8	15·9	34·2	118·2	211·3	109·4	77·5	84·4
August	18·0	13·9	75·5	93·8	163·7	145·0	81·8	80·7
September	14·0	14·6	70·8	80·0	135·1	130·2	84·0	81·5
October	7·8	8·7	54·1	128·7	93·1	70·4	87·6	86·6
November	4·2	3·4	29·8	63·0	56·3	67·4	89·9	62·4
December	3·0	3·6	80·7	43·0	19·1	41·0	89·5	86·8
Mean resp. sum	7·9	7·3	685·6	965·5	1 526·8	1 284·3	80·1	78·1

The following meteorological data were recorded at the Research Centre's own meteorological station.

Table 1 includes the meteorological data for the two test years.

The figures in Table 2 show how much the climatic data for the test years deviate from the ten-year mean.

Table 2: Climatic data for 1955 and 1956 in comparison with ten-year mean.

	1955	1956	1947—1956
Average temp. max. °C	11·9	10·9	12·8
min.	3·8	3·2	4·9
mean	7·9	7·3	9·0
Rainfall in mm	685·6	965·5	843·7
Sunshine in hrs.	1 526·8	1 284·3	—
r. h. in %	80·1	78·1	80·5
Atm. pressure in mm	746·2	747·9	746·3

Westerly winds predominate, and amount to 45 %.

2. Arrangement of test

The tests were conducted on 14-year-old apple bush trees of the Jonathan, Cox-Orange-Renette, Geheimrat Oldenburg, Ellison's Orange-Renette and Zuccalmaglio varieties. Until 1951 when the area was parcelled out, all the trees had received the same cultural treatment such as pest control, pruning and fertilization. The control measures carried out in the different plots after 1951, are listed in Table 3.

The plots were divided into the following groups:

1. U = plot not treated with fungicides and insecticides for many years.
2. O = plot treated with fungicides for many years; except for 1953, not treated with insecticides since 1951.
3. B = plot treated with fungicides and insecticides for many years.

(For the sake of simplicity, the abbreviations U =, O = and B = plot will be retained in the following sections.)

Table 3: Fungicidal and insecticidal spray applications in the test plots from 1950 to 1956.

	1950		1951		1952		1953		1954		1955		1956	
plot	F	I	F	I	F	I	F	I	F	I	F	I	F	I
U = plot	x	x	—	—	—	—	—	—	—	—	—	—	—	—
O = plot	x	x	—	—	x	—	x	x	x	—	x	—	x	—
B = plot	x	x	—	—	x	—	x	x	x	x	x	x	x	x

x = treated — = untreated F = fungicide I = insecticide

A detailed description of the spray sequence in the difference plots is given on Pages 180 and 181.

Pruning was carried out on all trees also after 1951, except in 1956 when the U = and O = plots were not pruned. Soil cultivation and fertilizing were also continued in all the test plots after 1951.

The layout of the test plots is illustrated in the following plan which also shows the location of the plots in relation to the prevailing direction of wind and to north:

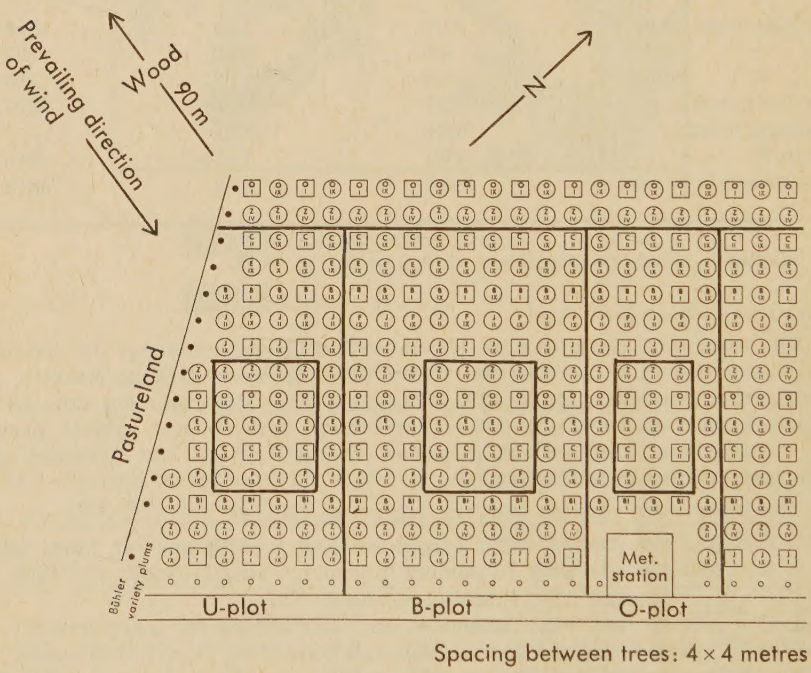


Fig. 2: Layout of test site at Höfchen, 1955—1956

In order to ensure that marginal and adjacent effects would be largely eliminated, one or two outside rows of trees were left out of the test in each plot. This gave a core of 20 trees in the U = plot, at least 25 trees in the B = plot, but only 12 trees in O = plot. The O = plot proved to be too small. Spray drift could not be avoided when the wind was blowing.

A factor of no mean importance to biocoenotic studies is also the location of the individual test plots in relation to each other, and their distance from biotopes of a different kind which are completely untouched by pesticides (see Fig. 2).

The U = plot is situated at the edge of the apple section. It also borders with untreated apple plots on its narrow sides (NW and SE). On the one broad side (NE), it borders with the B = plot. On its other broad side (SW), there is a row of Bühler plum trees (also sprayed) adjoined by a large pasture falling away to the south-west and west.

The B = plot, on the other hand, is surrounded by apple trees; in the NW and SE it is bordered by treated plots, and in the NE and SW by untreated plots, the U = and O = plots.

The O = plot, a narrow strip of trees, is bordered in the NE and SW by treated plots, and in the NW by an untreated plot; in the east section of this plot there is an area of densely growing ornamental shrubs (an overwintering ground for pests — blossom weevils) surrounding the meteorological station.

All the test plots are an equal distance (approx. 90 metres) away from the oak/hornbeam wood adjoining the orchard on the west side.

The evaluation of the stages of bud development on the test trees was carried out according to the diagram prepared by Soenen (1952), (Fig. 3).

Translated German terms according to Klemm (1948)

A = Change in colour of bud
B = Swelling
C = Burst
D = Mouse-ear
E = Green cluster
F = Separation of flower parts
G = Pink bud
H = Commencement of bloom
I = Full bloom
J = Petal fall

Fig. 3: Stages of bud development according to Soenen. Left: apple; right: pear

Details of bud development on the examined trees in 1955 and 1956 are given in Table 4.

Table 4: Bud development in Höfchen, 1955 and 1956 / stages according to Soenen.

Variety	Swelling		Unfolding				Bloom			
1955										
Jonathan	A	B	C	D	E	F	G	H	I	
Oldenburg	A	B	C	D	E	F	G	H	I	
Zuccalmaglio	A	B	C	D	E	F	G	H	I	
Cox Orange	A	B	C	D	E	F	G	H	I	
	20th March		1st April	10th	20th		1st May		10th	
1956										
Jonathan	A	B	C	D	E	F	G	H	I	
Oldenburg	A	B	C	D	E	F	G	H	I	
Zuccalmaglio	A	B	C	D	E	F	G	H	I	
Cox Orange	A	B	C	D	E	F	G	H	I	
	20th March		1st April	10th	20th		1st May		10th	20th

The dates of hatching and emergence for the most important pests occurring in the Höfchen orchard, and the corresponding stages of bud development are given in Table 5.

Table 5: Hatching dates of pests and stages of bud development in 1955 and 1956

	1955		1956	
	Date	Stage of development	Date	Stage of development
Anthonomus pomorum	29. 3.	A—B	26. 3.	A—B
Rhopalosiphum insertum	5. 4.	C	9. 4.	C
Olothreutes variegana	6. 4.	C	12. 4.	C
Pandemis ribeana	10. 4.	C	10. 4.	C
Doralis pomi	12. 4.	D	22. 4.	D
Psylla mali	12. 4.	D	25. 4.	E
Cheimatobia brumata	15. 4.	D	23. 4.	D—E
Nola cucullatella	26. 4.	F	21. 4.	D
Bryobia praetiosa	27. 4.	F	25. 4.	E
Metatetranychus ulmi	5. 5.	G	4. 5.	F—G
Phyllobius oblongus	5. 5.	G	9. 5.	G—H
Calymnia pyralina	5. 5.	G	4. 5.	F—G
Chloroclistis rectangulata	7. 5.	G	15. 5.	I

The following list provides full details of the weed flora in the test area together with their main flowering times:

	Month		Month
Polygonum aviculare	5— 6	*Lamium maculatum*	3—10
Polygonum persicaria	7—10	*Galeopsis ladanum*	7—10
Polygonum lapathifolium	7—10	*Stachys officinalis*	6— 8
Rumex acetosa	5— 6	*Veronica arvensis*	4—10
Rumex acetosella	5— 8	*Veronica agrestis*	8—10
Chenopodium album	7— 9	*Veronica polita*	4—10
Atriplex hastatum	7—10	*Antirrhinum ornitium*	7— 9
Stellaria media	5—10	*Plantago major*	6—10
Ranunculus repens	5— 7	*Senecio vulgaris*	3—10
Ranunculus arvensis	5— 7	*Senecio viscosus*	6—10
Sinapis arvensis	6— 7	*Matricaria chamonilla*	5— 8
Capsella bursa pastoris	3—10	*Matricaria suaveolens*	6— 8
Cardamine hirsuta	3— 5	*Gnaphalium silvaticum*	7— 9
Euphorbia helioscopia	6—10	*Taraxacum officinalis*	4— 5
Viola tricolor	5—10	*Erigeron canadensis*	6—10
Convolvus arvensis	6—10	*Sonchus asper*	7—10
Myosotis intermedia	6—10	*Poa annua*	2—11
Lamium purpureum	3—10	*Agropyrum repens*	6— 8

The shrubs growing around the meteorological station included plants of the following families:

Pinaceae (Juniperus, Thuja, Pinus, Picea), Taxaceae (Taxus), Berberidaceae (Berberis), Rosaceae (Cotoneaster, Potentilla, Rosa, Prunus), Papillionaceae (Cytisus), Celastraceae (Evonymus), Thymelaeaceae (Daphne), Ericaceae und Oleaceae.

3. Soil cultivation and fertilization

In view of the fact that each cultural practice constitutes an interference in the natural balance of the fauna, brief reference must, therefore, be made in this paper to the soil cultivation measures and fertilization carried out at Höfchen.

The soil cultivation work for regulating the supply of water, air and heat to the soil, was chiefly carried out between March and July, by using rotavator and cultivator equipment for turning and loosening the soil. This work was stopped during the very rainy months (from August onwards), and instead the emerging green vegetation was kept in check by regular mowing.

The annual fertilizer dosages were fixed in the test years according to soil analyses carried out by the Research Centre:

Organic fertilizers	20 000 kilos/hectare	stable manure
Mineral fertilizers	100 kilos/ha N	in pure nutrients
	110 kilos/ha P_2O_5	in pure nutrients
	180 kilos/ha K_2O	in pure nutrients

4. Pesticides used and dates of spraying

The prime object of the studies was to establish the effect of insecticidal sprays on the fruit tree fauna. It was only possible to give secondary consideration to the influence exerted on the fauna by fungicides.

Table 6: Dates of spray applications, concentrations of applied pesticides, and stages of bud development in 1955 and 1956.

1955	Insecticide	%	Stage of bud development	1955	Fungicide	%	Stage of bud development
6. 4.	FOLIDOL-E 605 forte	0·035	C	6. 4.	POMARSOL forte	0·2	C
2. 5.	FOLIDOL-E 605 forte	0·035	F	13. 4.	„	0·2	E
				4. 5.	„	0·2	F—G
				12. 5.	„	0·2	H—I
				24. 5.	„	0·2	
24. 6.	METASYSTOX	0·1		9. 6.	„	0·15	
				1. 7.	„	0·15	
				14. 7.	„	0·15	
26. 8.	FOLIDOL-E 605 forte	0·035		12. 8.	„	0·125	

1956	Insecticide	%	Stage of bud development	1956	Fungicide	%	Stage of bud development
24. 4.	FOLIDOL-E 605 forte	0·035	E	27. 4.	POMARSOL forte	0·2	E
8. 5.	METASYSTOX	0·1	F—G	8. 5.	„	0·2	F—G
				16. 5.	„	0·2	G—H
				26. 5.	„	0·2	
2. 6.	FOLIDOL-E 605 forte	0·035		8. 6.	„	0·15	
				13. 6.	„	0·15	
				20. 6.	„	0·2	
				2. 7.	„	0·2	
				17. 7.	„	0·2	
13. 8.	METASYSTOX	0·1		6. 8.	„	0·15	
30. 8.	METASYSTOX	0·1		31. 8.	„	0·15	

In the B = plot four insecticidal and nine fungicidal sprays were carried out in 1955, followed by five insecticidal and eleven fungicidal sprays in 1956.

The insecticides used were FOLIDOL-E 605 forte and METASYSTOX; POMARSOL® forte was applied as the fungicide.

The dates of the controls and the selection of the products used were adapted according to the general Höfchen Spray Programme; the treatments were carried out by operators of the Research Centre.

The sprays were applied by means of a Holder type p. t. o. pump Z 75, at a rate of 2500 litres of solution per hectare.

Table 7: Pesticides applied in the different test plots up to 1956.

	Year	U-plot	%	B-plot	%	O-plot	%
a) Winter sprays	1949	SELINON	1	SELINON	1	SELINON	1
	1950	695/11 (American winter oil)		695/11 (American winter oil)		DNOC tar oil	4
b) Fungicides	1950	POMARSOL	0·75	POMARSOL	0·75	POMARSOL	
	1951	—		—		—	
	1952	—		2 x Ob 21*	0·5	as for B-plot	
				7 x POMARSOL	0·75		
	1953	—		2 x Ob 21	0·3—0·1	as for B-plot	
				7 x POMARSOL	0·75		
	1954	—		1 x Ob 21	0·25	as for B-plot	
				1 x Bayer mercury	0·15		
				3 x POMARSOL Z-forte	0·15—0·1		
				7 x POMARSOL forte	0·2—0·15		
	1955	—		8 x POMARSOL forte	0·2—0·15	as for B-plot	
	1956	—		10 x POMARSOL forte	0·2—0·15	as for B-plot	
c) Insecticides	1950	FOLIDOL-E 605		POLIDOL-E 605		FOLIDOL-E 605	
	1951	—		—		—	
	1952	—		—		—	
	1953	—		3 x FOLIDOL-E 605	0·035	3 x E 605	0·035
	1954	—		4 x FOLIDOL-E 605	0·035	—	
				1 x METASYSTOX	0·1		
	1955	—		3 x FOLIDOL-E 605	0·035	—	
				1 x METASYSTOX	0·1		
	1956	—		2 x FOLIDOL-E 605	0·035	—	
				3 x METASYSTOX	0·1		

* = Cupravit.

5. Control methods

The following control methods were employed:

1. Binocular branch controls for overwintering stages of the most important pests and beneficial insects.
2. Bud and green cluster counts at the beginning of the vegetation period to establish the dates of hatching and to observe the population development of the different insects.
3. Tree jarring trap method.

4. Bait jar and yellow pan traps.
5. Sticky band corrugated paper band and glass traps.
6. Leaf controls for phytophagous and predaceous Acarida.
7. Mortality controls.

C. I. List of major pests and predators occurring in the test site at Höfchen during the growing seasons of 1955 and 1956.

(U = untreated plot, B = treated plot) and frequency of their occurrence in the U = plot.

A rough estimate was made of the frequency factor, whereby

x is understood to mean isolated occurrence
xx slight occurrence
xxx medium occurrence
xxxx frequent occurrence

1. Pests

Class:	*Insecta*				
Sub-class:	*Pterygota*				
Order:	*Rynchota*				
Suborder:	*Heteroptera*	*Plesiocoris rugicollis* Fall.	x	U	
		Dolycoris baccarum L.	x	U	
		Lygus pabulinus L.	xx	U	B
		Lygus pratensis L.	x	U	B
Suborder:	*Homoptera*				
	a) *Cicadina*	*Typhlocyba rosae* L.	xx	U	B
		Typhlocyba frogatti Bak.	xx	U	B
	b) *Psyllina*	*Psylla mali* Schm.	xx	U	
		Psylla pirisuga För.	x	U	
		Psylla pyricola För.	x	U	B
	c) *Aphidina*	*Aphis pomi* Deg.	xx	U	B
		Sappaphis mali Ferr.	xx	U	
		Rhopalosiphum insertum Wlk.	xxx	U	B
		Eriosoma lanigerum Hausm.	xxxx	U	B
	d) *Coccina*	*Lepidosaphes ulmi* L.	xxx	U	
		Eulecanium bituberculatum Targ.	xx	U	
		Eulecanium corni Bouché	x	U	
		Aspidiotus ostreiformis Curt.	x	U	
		Epidiaspis betulae Bär.	x	U	
Order:	*Hymenoptera*				
Suborder:	*Symphyta*				
Family:	*Tenthredinidae*	*Hoplocampa testudinea* Klug	x	U	
Suborder:	*Aculeata*				
Family:	*Vespidae*	*Vespa crabro* L.	xx	U	B
		Vespa vulgaris L.	xxx	U	B
		Vespa germanica Fabr.	xx	U	B

Order: *Coleoptera*				
Suborder: *Polyphaga*				
Family: *Curculionidae*	*Anthonomus pomorum* L.	xxx	U	B
	Phyllobius oblongus L.	xxxx	U	B
	Phyllobius piri L.	xx	U	B
	Rhynchites aequatus L.	x	U	B
	Rhynchites bacchus L.	x	U	B
	Rhynchites purpureus L.	x	U	B
	Rhynchites coeruleus Deg.	x	U	B
	Otiorrhynchus singularis L.	xx	U	B
	Peritelus griseus Oliv.	x	U	
Family: *Scarabaeidae*	*Phyllopertha horticola* L.	xx	U	B
	Rhizitrogus sestivus L.	xx	U	B
	Rhizitrogus solstitialis L.	xx	U	B
	Melolontha melolontha L.	x	U	B
Family: *Nitulidae*	*Meligethes aeneus* Fabr.	xxx	U	B
Family: *Ipidae*	*Eccoptogaster (Scolytus) mali* Bchst.	x	U	B
Order: *Lepidoptera*				
a) Microlepidoptera				
Family: *Tineoidae*	*Nepticula malella* Staint.	xx	U	B
	Nepticula aenella Hein.	x	U	B
	Lyonetia clercella L.	xx	U	B
	Lithocolletis blancardella F.	xxx		
	Lithocolletis corylifoliella Hw.	x		
	Cerostoma asperella L.	x	U	
	Cemiostoma scitella Z.	x	U	B
	Swammerdamia pyrella Vill.	xxx	U	B
	Ornix guttea Hw.	x	U	B
	Coleophora hemerobiella Sc.	xx	U	
	Coleophora nigricella Steph.	xx	U	
	Hyponomeuta malinella Zell.	xxxx	U	B
Family: *Tortricidae*	*Olothreutes variegana* Hb.	xxx	U	B
	Tmetocera ocellana L.	xx	U	B
	Pandemis ribeana Hb.	xx	U	B
	Pandemis ribeana ab. ceresana Hb.	xx	U	B
	Pandemis corylana F.	x	U	B
	Pandemis heparana Schiff.	xx	U	B
	Cacoecia podana Scop.	xx	U	
	Cacoecia podana ab. sauberiana	x	U	
	Cacoecia crataegana Hb.	xx	U	B
	Cacoecia xylosteana L.	xx	U	
	Cacoecia rosana L.	x	U	
	Cacoecia lecheana L.	x	U	
	Capua reticulana Hb.	xx	U	B
	Carpocapsa pomonella L.	x	U	B
	Pamene rhediella Cl.	xx	U	
	Ancylis achatana F.	xx	U	
	Acalla holmiana L.	x	U	B

	Acalla lipsana Schiff.	x	U	
	Tortrix viridana L.	xx	U	B
	Tortrix (Cnephasia) wahlbomiana L.	xx	U	
Family: *Sesiidae*	*Trochilium myopiforme* Bkh.	xx	U	B
	Trochilium vespiforme L.	x	U	B
	Trochilium conopiforme Esp.	x	U	
b) Macrolepidoptera				
Family: *Noctuidae*	*Calymnia pyralina* View.	xxx	U	B
	Calymnia trapezina L.	x	U	B
	Calymnia affinis L.	x	U	B
	Scopelosoma satellitia L.	xx	U	B
	Amphipyra pyramidea L.	xx	U	B
	Brachyonycha sphinx. Hüfn.	x	U	B
	Mamestra pisi L.	x	U	B
	Saturnia spini Schiff.	x	U	B
Family: *Geometridae*	*Cheimatobia brumata* L.	xxxx	U	B
	Cheimatobia boreata Hb.	xx	U	B
	Hibernia defoliaria Cl.	xxx	U	B
	Hibernia aurantiaria Hbn.	xx	U	B
	Hibernia marginaria F.	xx	U	B
	Boarmia gemmaria Brahm	xx	U	B
	Boarmia consortaria F.	xxx	U	B
	Larentia siterata Hufn.	x	U	B
	Chloroclistis rectangulata L.	xxx	U	B
	Biston pomonarius Hb.	xx	U	B
	Phigalia pedaria F.	x	U	B
Family: *Nolidae*	*Nola cuculatella* L.	xx	U	
Family: *Lymantriidae*	*Orgya antiqua* L.	xx	U	
Family: *Bombycidae*	*Malacosoma neustria* L.	x	U	B
Class: *Arachnoidea*				
Order: *Acari*				
	Metatetranychus ulmi Koch	xxxx	U	B
	Bryobia praetiosa Koch	xx	U	
	Eotetranychus pomi Sesp.	xx	U	
	Tetranychus urticae Koch	xx	U	
2. Beneficial insects				
Class: *Insecta*				
Sub-class: *Pterygota*				
Order: *Rhynchota*				
Suborder: *Heteroptera*				
Family: *Miridae*	*Deraeocorinae*			
	Deraeocoris ruber L.	xx	U	B
	Mirinae			
	Phytocoris dimidiatus Kb.	xxxx	U	B
	Phytocoris tiliae Fabr.	xx	U	B
	Phytocoris reuteri Saund.	xx	U	B

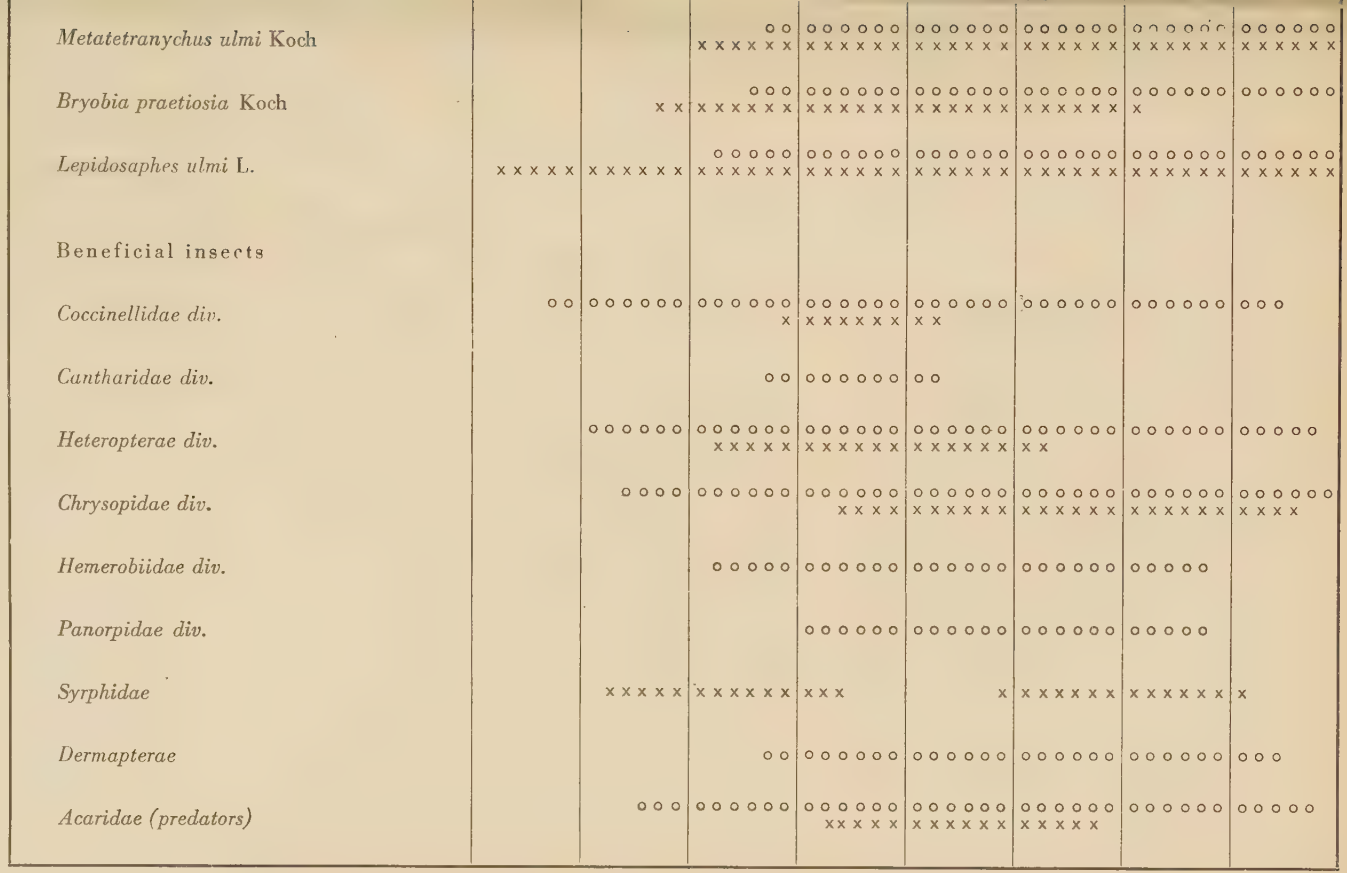
	Orthotylinae			
	Blepharidopterus angulatus Fall.	xx	U	
	Malacoris chlorizans Panz.	xx	U	B
	Orthotylus marginalis Reut.	xx	U	B
	Pilophorus perplexus D. a. S.	xxx	U	B
	Plagiognathinae			
	Psallus ambiguus Fall.	xx	U	B
	Atroctomus mali M.-D.	xx	U	B
	Diciphinae			
	Campyloneura virgula H.-S.	xx	U	
Family: *Anthocoridae*	*Anthocorinae*			
	Anthocoris nemorum L.	xxx	U	B
	Anthocoris nemoralis F.	xx	U	B
	Anthocoris confusus Reut.	xx	U	
	Orius minutus L.	xx	U	B
	Orius majusculus Reut.	xx	U	
Family: *Nabidae*	*Nabis apterus* F.	xx	U	
	Nabis ferus L.	xx	U	B
	Nabis pseudoferus Rem.	x	U	
Order: *Hymenoptera*				
Suborder: *Terebrantia*				
Family: *Ichneumonidae*		xxx	U	B
Family: *Braconidae*		xx	U	B
Family: *Chalcididae*		xxx	U	B
Family: *Cynipididae*		xx	U	B
Family: *Aphidiidae*		xx	U	B
Suborder: *Aculeata*				
Family: *Vespidae*	*Vespa crabro* L.	xx	U	B
	Vespa vulgaris L.	xxx	U	B
	Vespa germanica Fabr.	xx	U	B
	Vespa media Deg.	xx	U	B
	Vespa silvestris Scop.	x	U	B
Family: *Formicidae*	*Lasius sp.*	xxx		
	Formica sp.	xx		
	Myrmica sp.	xx		
Order: *Coleoptera*				
Suborder: *Adephaga*				
Family: *Carabidae*	*Carabus auratus* L.	xxx	U	B
	Carabus cancellatus Ill.	xx	U	B
	Carabus granulatus L.	xx	U	B
	Pterostichus vulgaris L.	xxx	U	B
	Dromius sp.	xx	U	B
	Nebria brevicollis Fbr.	x	U	B
	Calosoma sycophanta L.	x	U	
	etc.			

Suborder: *Polyphaga*				
Family: *Malacodermata*	*Cantharis fusca* L.	xxx	U	B
	Cantharis pellucida Fbr.	xx	U	
	Cantharis nigricans Müll.	xx	U	
	Cantharis obscura L.	xx	U	
	Cantharis rustica Fall.	xxx	U	B
	Cantharis rufa L.	xx	U	B
	Cantharis pallida Goeze	x	U	
	Cantharis livida L.	x	U	B
	Cantharis discoidea Ahr.	x	U	
	Rhagonycha fulva Scop.	xx	U	B
	Rhagonycha spec.	xx	U	B
Family: *Cleridae*	*Trichodes apiarius* L.	xx	U	B
Family: *Coccinellidae*	*Coccinella bipunctata* L.	xxx	U	B
	Coccinella bip. a. 4-maculata Scop.	x	U	B
	Coccinella bip. a. 6-punctata L.	x	U	B
	Coccinella 5-punctata L.	x	U	B
	Coccinella 7-punctata	xxx	U	B
	Coccinella 10-punctata L.	xx	U	B
	Coccinella 14-pustulata L.	x	U	B
	Halyzia 14-punctata L.	xx	U	B
	Halyzia 14-guttata L.	xx	U	B
	Exochomus 4-pustulatus L.	x	U	B
	Hippodamia 7-maculata D. G.	x	U	B
	Hippodamia sp.	x		
	Scymnus bipunctatus Kug.	xx	U	B
Family: *Staphylinidae*	*Tachyporus obtusus* L.	xxx	U	B
	Tachyporus hypnorum F.	xxx	U	B
	Staphylinus caesarius Cederh.	xx	U	B
Order: *Neuroptera*				
Suborder: *Planipennia*				
Family: *Chrysopidae*	*Chrysopa vulgaris* Schn.	xxxx	U	B
	Chrysopa perla L.	xx	U	B
	Chrysopa vittata Wesm.	x	U	B
	Chrysopa septempunctata Wesm.	x	U	
	Chrysopa sp.	x	U	B
Family: *Hemerobiidae*	*Drepanopteryx phalaenoides* L.	xx	U	B
	Hemerobius micans Oliv.	x	U	B
	Hemerobius nitidulus Fabr.	x	U	B
	Hemerobius humuli L.	x	U	B
	Hemerobius sp.	xx	U	B
	Boriomyia nervosa Fabr.	xxx	U	B
	Boriomyia concinna Steph.	x	U	B
	Boriomyia quadrifasciata	x	U	B
	Micromus variegatus Fabr.	xx	U	B
	Micromus pagamus L.	x	U	B

Order: *Mecoptera*	*Panorpa communis* L.	xxx	U	B
	Panorpa cognata Ramb.	x	U	B
Order: *Diptera*				
Suborder: *Orthorrhapha*				
Family: *Cecidomyidae*		xx	U	
Suborder: *Cyclorrhapha*				
Family: *Syrphidae*	*Lasiopticus seleniticus* Meig.	xx	U	B
	Lasiopticus pyrastri L.	xxx	U	B
	Syrphus balteatus Deg.	xxx	U	B
	Syrphus ribesii L.	xxx	U	B
	Syrphus vitripennis Meig.	xx	U	B
	Syrphus tricinctus Fall.	xx	U	B
	Syrphus venustus	x	U	B
	Syrphus cinctellus Zeff.	x	U	B
	Syrphus auricollis Meig.	x	U	B
	Syrphus bifasciatus Fabr.	x	U	B
	Paragus bicolor F.	x	U	B
	Sphaerophoria sp.	x	U	B
	Platychirus peltatus Meig.	x	U	B
	Platychirus longustatus Zeff.	xx	U	B
	Melanostoma sp.	x	U	B
	etc.			
Family: *Asilidae*		xx	U	B
Family: *Tachinidae*		xxx	U	B
Order: *Lepidoptera*				
Family: *Noctuidae*	*Calymnia trapezina* L.	x	U	B
	Scopelosoma satellitia L.	xx	U	B
Class: *Arachnoidea*				
Order: *Acari*				
Suborder: *Parasitiformes*				
Family: *Phytoseiidae*	*Typhlodromus tiliae* Oud.	xx	U	B
	Typhlodromus tiliarum Oud.	xx	U	B
	Typhlodromus vitis Oud.	x	U	
	Typhlodromus sp.	xx	U	B
Family: *Raphignatidae*	*Mediolata mali* Ew.	xxx	U	B
Suborder: *Trombidiformes*				
Family: *Anystidae*	*Anystis baccarum* L.	xx	U	B
	Anystis sp.	xx	U	
Family: *Cheyletidae*	*Cheyletus sp.*	xx	U	
Family: *Bdellidae*	*Bdella sp.*	x	U	
Family: *Trombidiidae*	*Trombidium holosericeum* L.	xx	U	
	Allothrombium fulliginosum Herm.	xx	U	
	Trombidium sp.	xx	U	
Order: *Araneina*		xxx	U	B
Order: *Opiliones*		xxx	U	B

C. II. Major pests and beneficial insects of an apple tree with respect to their seasonal occurrence.

Pest	March	April	May	June	July	August	September	October
Anthonomus pomorum L.	o o o o	o o o o o o	o o o o o o x x x x x x	o o o o o o	o o o o o o			
Phyllobius oblongus L.			o o o o o o	o o o o o o	o o o o o o			
Phyllopertha horticola L.			o o o o o o	o o o				o o o
Cheimatobia brumata L.		x x x x	x x x x x x	x x x x				
Chloroclistis rectangulata L.			x x x x	x x x x x x	x			
Geometridae div.		x x x	x x x x x x	x x x x x x	x x x x x x	x x x x x x	x x x	
Calymnia pyralina View.			x x x x x x	x x x x x x	x x x x			
Hyponomeuta malinella Zell.		x x x x x x	x x x x x x	x x x x x x	x x x o o o	o o o o o o	o o o o o o	
Tortricidae div.		x x x x x x	x x x x x x	x x x x x x	x x x x x x	x x x x x x	x x x x x	
Psylla mali Sch.		x x x x x x	x x x x x o	o o o o o o	o o o o o o	o o o o		
Aphis pomi Deg.		x x x x x x	x x x x x x	o o o o o o x x x x x x	o o o o o o x x x x x x	o o o o o o x x	o o o o o o	o o
		x x x x x x	x x x x x o	o o o o o o			o o o	o o o o o



x x x = larvae o o o = imagines

D. Studies on the effect of insecticides on the major pests and beneficial insects at Höfchen

The terms pests, beneficial insects and neutral organisms, used in this section, may be defined as follows. Pests are understood in this paper to mean (according to Eidmann, 1941) organisms which, by feeding, sucking and biting cultivated plants, may cause damage, yield reductions or death of the plants they attack, in other words such organisms which, by harming objects of economic importance, are of no advantage to humanity. Schwertfeger (1944) defines pests as phytopathogenic organisms.

The term "beneficial insects" is understood to include only those predominantly animal organisms which feed and reproduce at the expense of pests (Schneider, 1954), in other words which are of advantage to man and his economic endeavours (Eidmann, 1941).

Neutral organisms are those which economically are completely indifferent (Brauns, 1953), in other words which inflict no economic damage, and which are not known to be directly related to pests (Schwertfeger, 1957).

1. Binocular branch controls for overwintering stages of pests and beneficial insects

On four different occasions in autumn and during the winter months (September, October, December and March), one metre of fruit wood was cut from 12 trees in each of the untreated and treated plots, and examined under a binocular in the laboratory. Sampling was carried out according to the method evolved by Bachmann (1954) and Vogel (1956): To cut from each of 10 two to four-year-olds, 20 cm long branch pieces, well trimmed with short fruit wood or fruit scale.

The result of the branch controls carried out in December for overwintering stages of the major pests occurring at Höfchen — such as *Aphidae, Psyllidae, Geometridae, Hyponomeutidae and Coccidae* — is plotted in Fig. 4 (*Metatetranychus ulmi* is dealt with separately).

The height of the different blocks corresponds to the average pest infestation on untreated and treated trees.

The numbers of overwintering stages found in the B = plot, with the exception of *Aphidae,* were considerably lower in each of the three years than in the U = plot.

Apart from *Aphidae* eggs and *Hyponomeuta* pods, hardly any overwintering stages of other pests were found in the treated plot, whereas in the untreated plot numerous overwintering stages of *Psyllidae, Geometridae, Noctuidae, Tortricidae, Coleophoridae* and *Coccidae* were also counted.

The generally smaller pest population in the cultivated plot is undoubtedly due to regular control operations, and need not be further discussed here. The only outstanding feature is the more severe *Aphidae* infestation in the treated plot in the winters of 1954/55 and 1955/56.

The larger numbers of eggs in the treated plot as against the untreated plot, confirm the observations made by Ripper (1944), Vogel (1956) and other authors that *Aphidae* tend to occur more frequently in cultivated plantations than they do in uncultivated orchards.

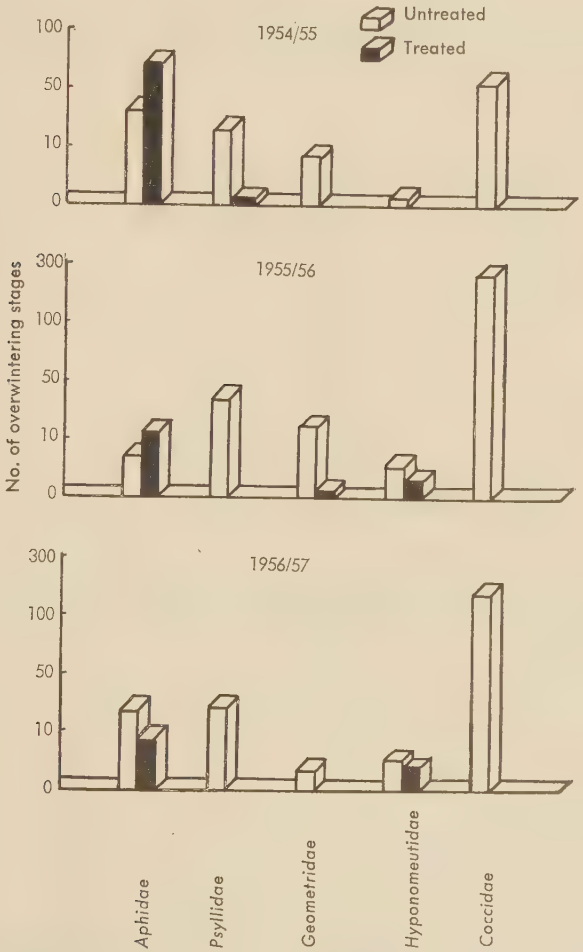


Fig. 4: Average pest infestation on one metre of fruit wood sampled from treated (black blocks) and untreated trees (white blocks) in December 1954—1956 (N = 12)

The reason put forward for the increased oviposition of *Aphidae* in cultivated orchards is that the natural enemies of these pests are killed by insecticidal chemicals. But in Höfchen the position appears to be different. The most abundant species among the *Aphidae* found in the branch controls, was *Rhopa-*

losiphum insertum Wlk., an aphis which, according to Schneider (1957), lives on apples only up to May or early June, then spends the summer months colonizing grass roots, and does not return to apple trees for egg-laying until mid-September. Thus, the return flight to apple trees takes place at a time when the feeding conditions for *Aphidae* in the treated plot, by virtue of regular tree cultivation, are far more favourable than in the untreated plot. The presence of fresh foliage over a longer period in the treated plot may largely account for the increased occurrence of aphids in late autumn and for the laying of greater numbers of winter eggs in this section (see Table 8).

Table 8: Aphis infestation in late autumn and winter 1954—1956. Average rate of infestation: imagines and larvae on 40 leaves (N = 160).

1954			1955			1956		
Date	untreated	treated	Date	untreated	treated	Date	untreated	treated
						20. 9.	6	0·5
			29. 9.	4	3	30. 9.	96	21
			5. 10.	25	12	5. 10.	122	30
9. 10.	74	48	14. 10.	74	53	11. 10.	210	96
22. 10.	235	516	20. 10.	115	110	23. 10.	206	35
			26. 10.	66	168			
3. 11.	0	47	2. 11.	0	70	2. 11.	0	8

Average no. of eggs on one metre of fruit wood (N = 12)

Winter 1954/55		Winter 1955/56		Winter 1956/57	
untreated	treated	untreated	treated	untreated	treated
33	66	7	13	23	8

No explanation was found for the completely different test result obtained in autumn and winter 1956/57.

Fig. 5 illustrates the rate of winter egg-laying by *Metatetranychus ulmi* Koch, the fruit tree spider mite.

The numbers of eggs counted in the treated plot were larger than those recorded for the untreated plot in each of the three test years, with exception of the September counts.

The larger number of eggs counted in the U-plot in September indicates that winter eggs are laid earlier in the uncultivated section. For example, on Sept. 17, 1955 (see Fig. 5), 810 eggs were counted per metre of fruit wood in the U-plot, whereas in the B-plot only 90 winter eggs were found. It would thus appear that the difference in the time of egg-laying by *M. ulmi* Koch

(laying of winter eggs in the untreated plot appears to take place about one month earlier than in the treated plot) is brought about by the varying feeding conditions in late autumn (see also P. 232). The trees in the treated plot were still full of fresh, green foliage in September and October, whereas the foliage in the untreated plot was already beginning to wither at this time, thus providing inadequate feeding conditions for *Tetranychidae*.

The larger number of eggs of *M. ulmi* Koch generally found in the treated plot, as compared with the untreated check, an observation referred to by many authors (see survey of pertinent literature on P. 170—173), corresponded

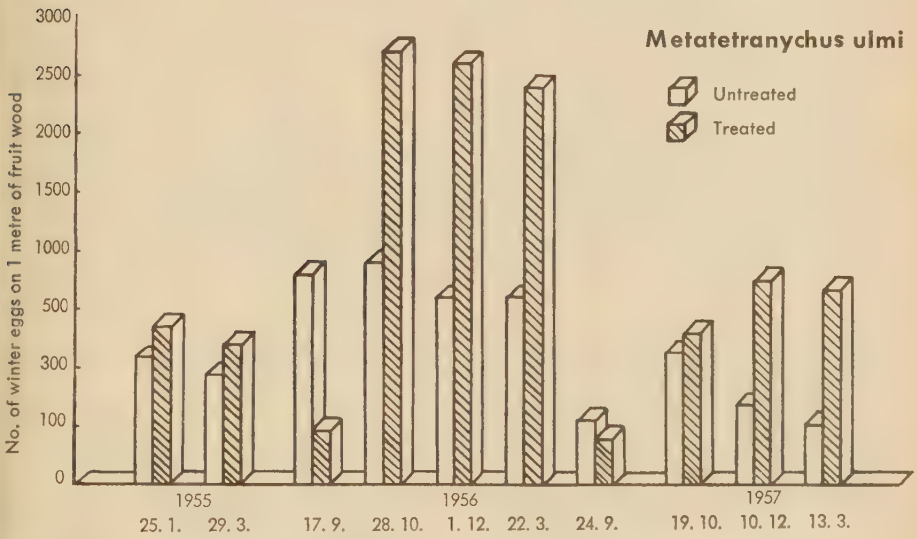


Fig. 5: Average no. of winter eggs of *Metatetranychus ulmi* Koch on one metre of fruit wood sampled from treated and untreated trees, winter 1954/55—1956/57 (N = 12)

to the likewise greater population density established at the end of the preceding vegetation season (see Figs. 24 and 25). The greater abundance of spider mites in the B-plot may be accounted for, on the one hand, by the more favourable feeding conditions resulting from regular cultivation of the trees, on the other hand by the absence of predators, and perhaps also by a direct influence of the applied pesticides on the mites.

In the untreated plot, however, unfavourable feeding conditions and the activities of predators permitted the development of only a small *M. ulmi* population, and moreover few winter eggs were laid.

It is worth mentioning that during the autumn counts, especially in October, it was observed that there were far more sucked-out winter eggs than healthy ones in the untreated plot, an indication that a high percentage of eggs laid in the untreated plot are destroyed shortly after oviposition (see also Berker,

1955). In the treated plot, on the other hand, only very few sucked-out winter eggs of *M. ulmi* Koch were found. *Anthocoris nemorum* L. and *Mediolata mali* Ewing were undoubtedly primarily responsible for this destruction of spider mite eggs in late autumn.

It was observed that there was only a slight decrease in the numbers of spider mite eggs laid in both the treated and the untreated plot during the period from November to March — this is evident from Fig. 5 — indicating that the natural enemies interrupt their activities in these months.

There were no overwintering stages of predators at all in the treated plot whereas a large number of predaceous mite colonies and midge larvae, also numerous bug eggs were found in the untreated plot.

2. Bud and green cluster counts

The following procedure was adopted for carrying out the bud counts. A total of 100 bud shoots were sampled every two or three days from the start of the vegetation season until the bloom period (mid-May) from all sides and all crown parts on each of five trees in the treated and the untreated plots, and examined under a binocular for infestation of pests and beneficial insects.

Table 9: Commencement of hatching of *Rhopalosiphum insertum* Wlk. and *Psylla mali* Schm. 1955—1957.

	Rhopalosiphum insertum			*Psylla mali*		
	Hatching begins on	Stage of bud development	Mean temp. from 1.1. until hatching begins, in °C	Hatching begins on	Stages of bud development	Mean temp. from 1.1. until hatching begins, in °C
1955	4.4.	C	1·0	12.4.	D	1·6
1956	9.4.	C	— 0·1	25.4.	D—E	0·5
1957	13.3.	C	4·2	19.3.	D	4·5

These studies enabled the hatching dates to be determined exactly for the different insects, thus providing information which is of importance for the correct timing of pesticide applications (see P. 178). The hatching dates in 1955 were all earlier than those recorded for 1956. The actual dates of hatching largely depend upon the weather conditions, and appear to be concurrent with the growth of the fruit trees (stages of bud development). The following table gives, by way of example, the dates for the commencement of hatching of

Rhopalosiphum insertum Wlk. and *Psylla mali* Schm. in relation to the temperature and the stages of bud development.

Observations carried out over the last few years have shown that *Rhopal. insertum* Wlk. starts to hatch in Höfchen as soon as the greater majority of

Table 10: Bud and green cluster counts in spring 1955 and 1956. Average pest infestation on 20 buds (N = 100).

				untreated				treated			
	Stage of bud development	Mean daily temp. in °C	Min. temp. in °C	*Aphidae*	*Psyllidae*	*Geometridae*	*Tortricidae* and other caterpillars	*Aphidae*	*Psyllidae*	*Geometridae*	*Tortricidae* and other caterpillars
1955											
2. 4.	B	4·9	—2·0	0·0	0·0	0·0	0·0	0	0	0	0
4. 4.	B—C	8·9	6·0	1·0	0·0	0·0	0·0	4	0	0	0
6. 4.	C	12·3	6·0	8·0	0·0	0·0	0·5	28	0	0	0
								FOLIDOL-			
9. 4.	C	7·2	5·0	15·5	0·0	0·0	0·0	6. 4.	E 605 f at 0·035 %		
12. 4.	D	9·8	7·0	50·0	0·2	0·0	0·5	0	0	0	0
15. 4.	D	5·5	0·5	86·0	1·5	1·0	1·0	0	0	0	0
18. 4.	D—E	5·9	—1·5	138·0	32·0	2·0	0·0	0	0	0	0
21. 4.	E	3·7	0·0	63·0	20·0	2·0	0·0	0	0	0	0
25. 4.	E—F	4·5	—1·0	49·0	49·0	2·0	1·0	0	0	0	0
								FOLIDOL-			
29. 4.	F	21·0	13·0	16·0	11·0	2·5	1·0	2. 5.	E 605 f at 0·035 %		
5. 5.	G	10·0	9·0	8·0	8·0	4·5	1·0	0	0	0	0
1956											
9. 4.	C	7·2	2·0	2·0	0·0	0·0	0·0	4·0	0	0	0
12. 4.	C—D	8·5	3·0	7·0	0·0	0·0	1·0	27·0	0	0	0
17. 4.	D	1·3	—1·0	18·0	0·0	0·0	0·0	93·0	0	0	0
23. 4.	D—E	7·0	—1·5	10·0	0·0	2·0	0·0	67·0	0	0	0
								FOLIDOL-			
25. 4.	D—E	6·0	0·5	32·0	7·0	5·0	0·5	26. 4.	E 605 f at 0·035 %		
29. 4.	E	6·7	2·6	49·0	11·0	11·0	0·0	0·0	0	0	0
2. 5.	E—F	6·5	0·5	6·0	26·0	15·0	1·0	0·0	0	0	0
7. 5.	F—G	16·0	6·0	2·0	10·0	10·0	1·0	0·0	0	0	0
11. 5.	G	12·0	7·0	1·5	9·0	43·0	2·0	8.5.	METASYSTOX at 0·1 %		

buds have reached the C-stage. It was observed that the first *Psyllidae* larvae appeared at bud stage D (mouse ear).

The bud counts also enable the population density of pests and predators in the different test plots to be established.

Table 10 gives details of the average pest infestation and the influence exerted upon it by insecticidal chemicals and climatic factors.

The population density of *Aphidae* in the treated plot at the start of the vegetation period was much greater than in the untreated plot, in keeping with the greater deposit of winter eggs (see P. 193). However, following the pre-blossom sprays of FOLIDOL-E 605 forte on April 6, 1955 and April 24, 1956 no more apple aphids were found until autumn in the treated section. *Psyllidae, Geometridae* ond other pests which were more or less abundant in the U-plot, were unable to develop due to the applications of poison in the B-plot.

A most appreciable decrease in the population density was also observed in the untreated plot between the middle and end of April in both years. This may be attributed to the prevailing weather (ten days of cold weather from April 14—25 in 1955, and from April 15—25 in 1956) and the predaceous activities of the beneficial insects *(Coccinellidae* imagines, *Heteroptera* and *Syrphidae* larvae).

No beneficial insects at all were counted on the bud shoots from the treated plot, and only a few in the untreated plot, these including *Coccinellidae* adults, eggs and larvae of *Syrphidae* and *Heteroptera.*

Green cluster counts carried out shortly before the blossom (400 per plot) provided the following results:

Table 11: Green cluster counts carried out in May 1955 and 1956 (400 per plot).

	May 11, 1955		May 14, 1956	
	untreated	treated	untreated	treated
Pests				
Cheimatobia brumata	176	7	284	0
Chloroclistis rectang.	33	0	23	0
other *Geometridae*	8	0	11	0
Tortricidae	21	0	18	0
Noctuidae	8	0	12	0
Aphidae	245	0	51	0
Psyllidae	85	0	52	0
Anthon. pomorum (larvae)	163	12	93	13
Beneficial insects				
Syrphidae (larvae)	14	0	5	0
Coccinellidae	7	0	3	0
Staphylinidae		0	5	0
Neutral insects				
Thrips	0	21	3	18
Diptera (imagines)	6	27	5	12

The counts revealed, therefore, that in the treated plot there were only very few pests, no predators at all, and only few neutral species although more than in untreated plots.

Considerably more pests and beneficial insects were counted in the untreated check than in the treated plot.

More green cluster counts were carried out in the middle of May to check the population density of *Anthonomus pomorum* L. (8 × 100 green clusters per plot).

The degree of infestation on the different apple varieties did not vary appreciably.

The difference in blossom infestation between the treated and untreated plots is evident from the data tabulated below.

Table 12: Infestation of blossoms by *Anthonomus pomorum* L. (larvae) in treated and untreated plots, 1955 and 1956.

		Infestation in %	Reduction of infestation in %
1955	treated	5·5	— 85·7
	untreated	38	
1956	treated	8	— 68
	untreated	25	

The infestation of blossoms in 1955, in keeping with the larger numbers of weevils that were trapped (see P. 205), was more severe than in the following year. Far more buds were attacked in the untreated plot than in the sprayed section.

In order to study the parasitization of *A. pomorum* L. larvae in the different plots, 500 "burnt" blossoms were sampled from each plot, and later examined in the laboratory.

The counts produced the following results:

Table 13: Parasitization of *Anthonomus pomorum* L. larvae in May, 1955 and 1956.

	Parasitization/500 larvae	
	1955	1956
untreated	235	104
treated	119	54

The parasites were primarily *Hymenoptera (Ichneumonidae)* and fungi. They were not, however, identified more closely.

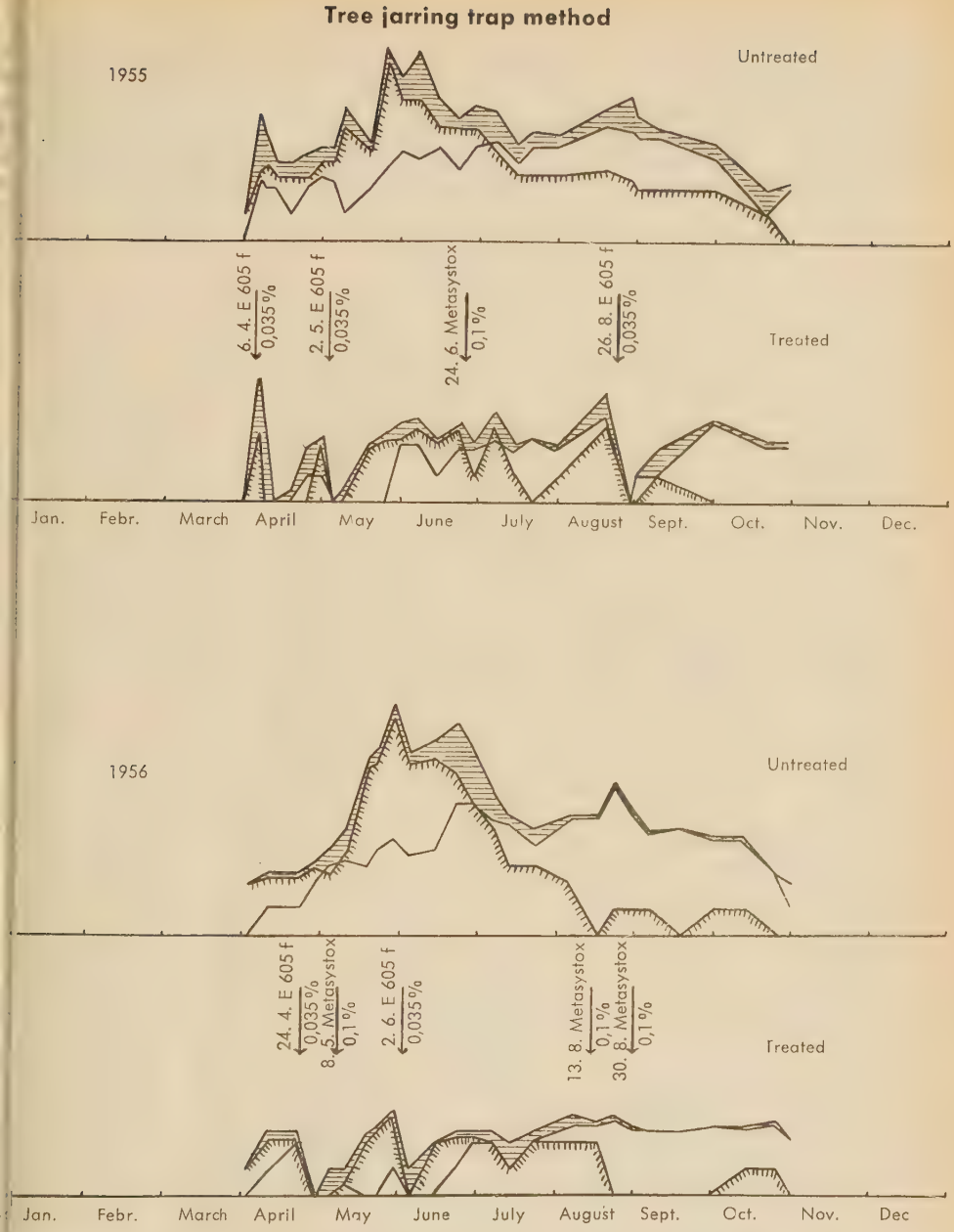
3. Tree jarring trap method

In order to investigate the question as to what extent pests and beneficial insects living freely in an orchard, are influenced by insecticides, insects were dislodged from the trees by jarring the branches with a heavy stick at regular intervals throughout the vegetation season, and caught in oilcloth sheets of a given size (see Fig. 6) spread out always at the same spots beneath the trees. The trapping operations were carried out at weekly intervals, whenever possible in the early hours of the morning, and always on the

Fig. 6: Trap sheets

same trees which, incidentally, were not used for other studies. (The blossom weevil observations at the beginning of the vegetation season were carried out more often — every two or three days — but on separate trees.)

The pests caught by this method were primarily *Coleoptera* and caterpillars. The trapped predators included *Heteroptera, Neuroptera, Coleoptera, Dermaptera and Araneidae. Homoptera, Hymenoptera and Diptera* could not be caught with adequate certainty by means of the tree jarring method, and are not given consideration in the following remarks.



Results of tree jarring trap in treated and untreated plots, in 1955 and 1956, with special consideration to pests and predators. Total = pests + predators + neutral insects. Ordinate: average no. of insects per 3 sq. m. of trap area

The total tree jarring trap results for 1955 and 1956 are plotted in Fig. 7.

The ordinate gives the average number of insects caught per 3 square metres of trap area, and the time factor is plotted on the abscissa. Pests and beneficial insects are entered separately. (Neutral species were also trapped but they will not be taken into consideration here.)

The curves illustrate the normal development of population in the untreated plot as against a greatly changed population development in the

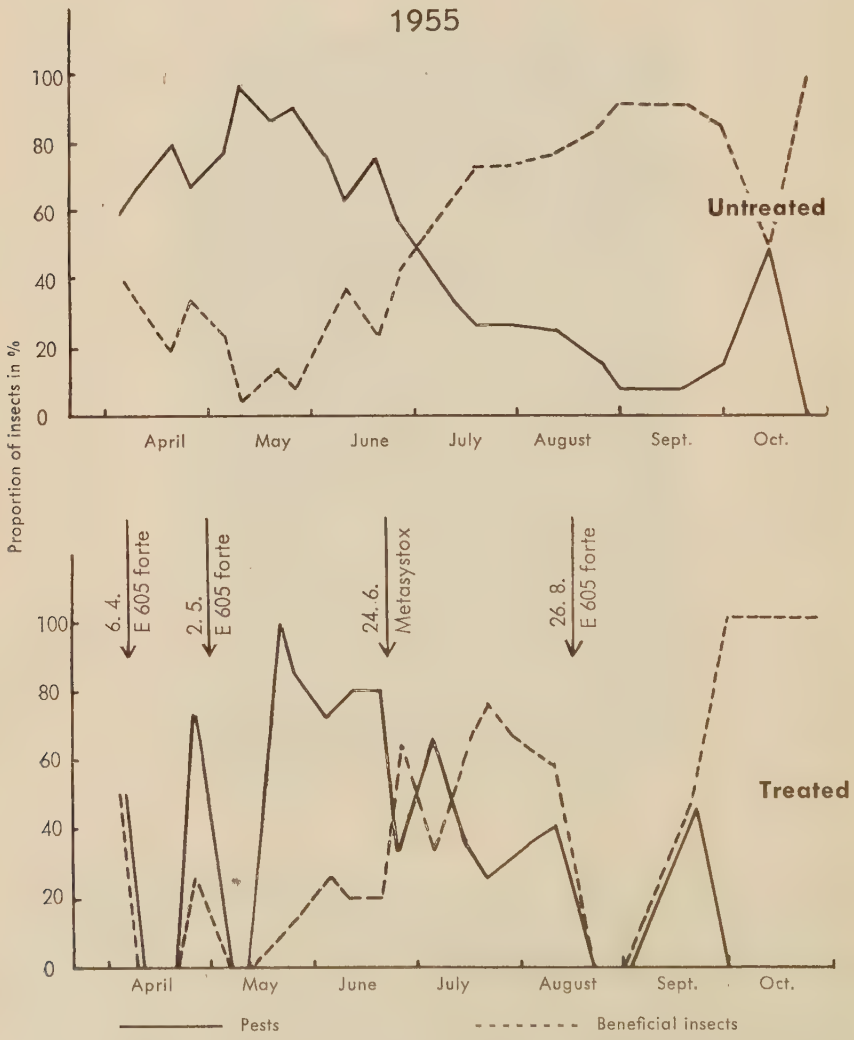


Fig. 8a: Percentage ratio of pests and beneficial insects caught by tree jarring trap method in 1955

treated plot. The marked fluctuations of the population curves for the treated plot may be primarily attributed to the applications of insecticides (see dates of spraying). It is quite obvious that FOLIDOL-E 605 forte had a much greater influence than METASYSTOX on the pest and predator fauna covered by these tests, but even here a recolonization was observed which started after two weeks at the latest, brought about either by insects still left in the treated section or by migration from the adjoining untreated plot. The application of

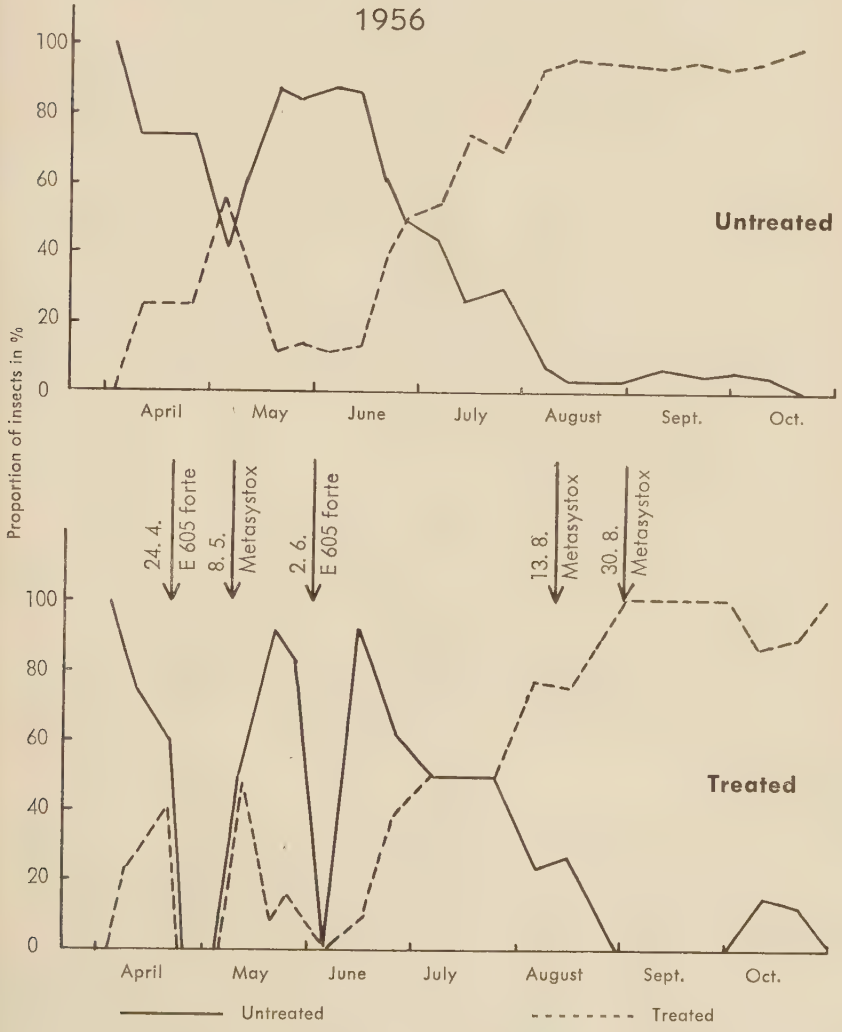


Fig. 8b: Percentage ratio of pests and beneficial insects caught by tree jarring trap method in 1956

METASYSTOX caused only slight fluctuations of the population curves. The beneficial insects appeared to be only slightly, or not at all influenced by this pesticide. The curves began to rise again already one week after the application of poison.

In contrast to the insecticidal controls, applications of fungicide caused no perceptible change of the fruit tree fauna. At all events, the results obtained by the tree jarring trap method following the different applications of poison showed no appreciable variations as against the previous values.

The ratio of harmful to beneficial insects caught by means of the tree jarring trap method, is plotted in Fig. 8.

It must be taken into consideration that the trapped predators are not exclusively enemies of the noxious insects referred to in this section, so that there is no direct correlation between the pests and beneficial insects for which these graphs have been plotted.

A striking feature which, however, is most evident in the untreated plot, in the shift in the pest : predator ratio during the course of the vegetation season. Whereas more pests than beneficial insects were trapped in spring, the position was reversed in summer and autumn when more beneficial insects than pests were counted in the plots. The turning point, in other words, the time when pests and beneficial insects were present in equal abundance, was at the end of June in both test years. The renewed increase of pest infestation observed in September and October in 1955 may be explained as resulting from another migration of caterpillars — carried by the wind — into the test plot, while the temporary increase in the population of beneficial insects in early May of 1956 may be attributed to the presence of numerous *Coccinellidae* at that particular time.

The total numbers of pests and beneficial insects caught by the tree jarring trap method in 1955 and 1956 are given in the following table.

Table 14: Tree jarring trap method: Average and relative nos. of insects trapped in an area of 3 sq. m. in the vegetation season of 1955 and 1956 (N = 30).

	Average no. trapped				Rel. no. trapped	
	untreated		treated		untreated	treated
	pests	predators	pests	predators	pests : predators	
1955	240	97	31	32	2·5 : 1	1 : 1
1956	323	233	23	37	1·6 : 1	0·6 : 1

It is noticeable that there were many more pests than predators in the untreated plot, whereas in the treated plot they occurred in approximately equal abundance.

Out of the pests caught by the tree jarring trap method, the individual results will be given, by way of example, only for *Anthonomus pomorum* L., *Phyllobius oblongus* L. and several *Lepidoptera* caterpillars. The point of prime interest in these studies was to establish how and at what speed the "biological vacuum" created by the application of poisons, is recolonized.

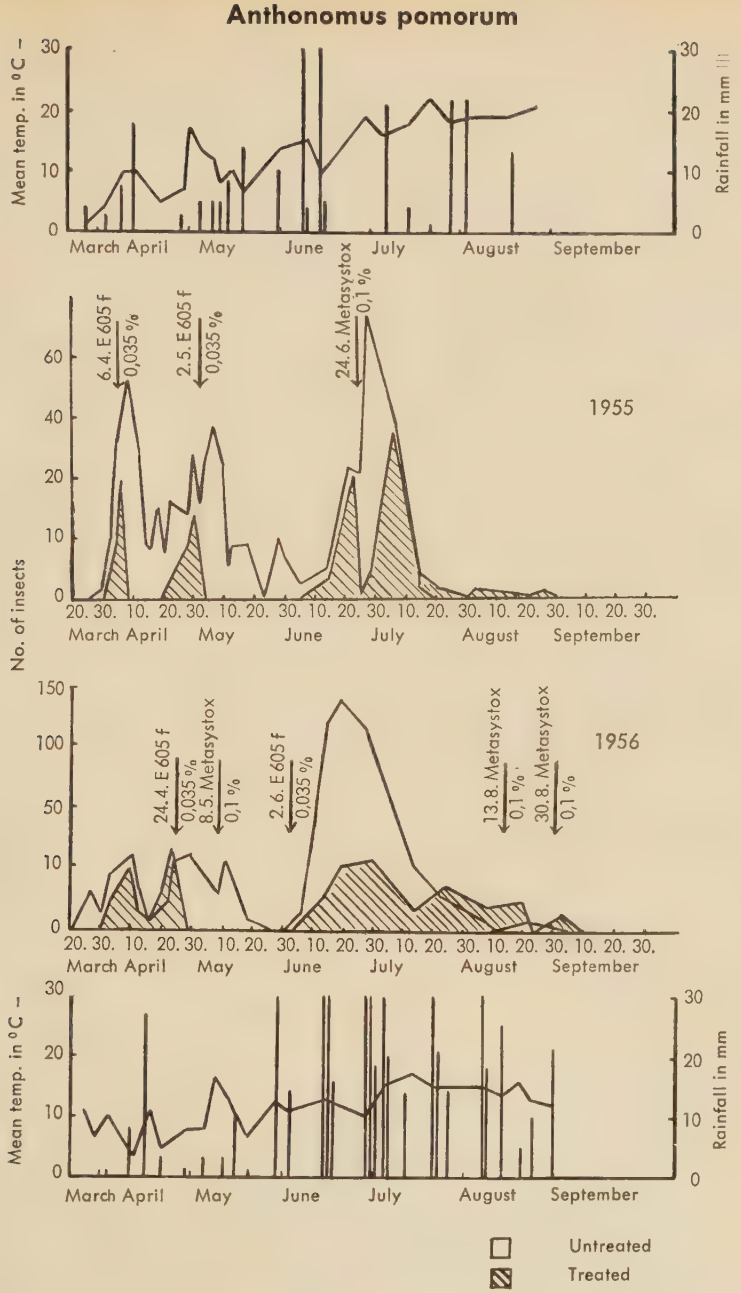


Fig. 9: *Anthonomus pomorum* L. on treated and untreated trees in 1955 and 1956. (Ordinate: No. of weevils on 10 trees. Abscissa: Date)

Anthonomus pomorum L.

Fig. 9 illustrates the development of the population of *A. pomorum*, and the influence exerted upon it by the application of chemical pesticides, and also the dependence of weevil migration upon temperature and rainfall.

The migration of *A. pomorum* from its overwintering quarters started during the last week of March in the two test years of 1955 and 1956. On the other hand, in 1957, the weevil was already observed on the trees in mid-March, this being due to the unusually favourable spring weather. At this time, the buds had reached the B-stage (breaking) in all three years (see P. 178). Oviposition, which was followed by constantly preparing the ovaries of freshly trapped weevils according to the method of Unterstenhöfer (1948), commenced in both test years about three weeks after the first weevils appeared (bud stage E—F). In 1955, the first larvae of *A. pomorum* were found on May 5 (bud stage F), and in 1956 on May 18 (bud stage G). The young weevils emerged in the first week of June in both test years, and were observed on the apple trees until mid-August.

Test results 1955

The first pre-blossom spray carried out on April 6 with FOLIDOL-E 605 forte was so effective that no apple blossom weevils were found in the treated plot for three weeks. Renewed colonization of this plot by *A. pomorum*, which started in late April, was quickly suppressed by the second pre-blossom spray. The plot remained free of infestation until early June. A marked reduction of the population density was also observed in the untreated plot about the middle of May, which may be attributed to the normal mortality of the old weevils at this time of the year.

The steep rise of the population curves, equal for both plots in early June, may be accounted for by the emergence or migration of the new generation.

METASYSTOX, applied on June 24, suppressed *A. pomorum* infestation in the treated plot for only four days, as compared with the residual effect of three weeks given by the two earlier FOLIDOL-E 605 sprays. This may be attributed firstly to the weak effect of the product against *Coleoptera*, and secondly to the fact that only young weevils were present at the time, which fly more actively than old weevils.

On July 7, two weeks after the spray, the curve for the treated plot was again level with that for the untreated check.

Test results 1956

The results obtained in 1956 were similar to those recorded the previous year, except that the population density was extremely small at the beginning of the vegetation season in both the untreated and the treated plot, due to the low spring temperatures (early and late April). Following the application of the two pre-blossom sprays, no apple blossom weevils were observed in the treated plot until early June, just as in the preceding year.

An application of FOLIDOL-E 605 forte in June, at a time when the trees are colonized only by young weevils, suppressed infestation in the treated plot, just like METASYSTOX (see test results for 1955), for only four days; at the end of this period, the weevils started to colonize the trees again.

The test revealed, therefore, that old weevils commenced to recolonize the plot at the earliest three weeks after a spray, whereas a recolonization by young weevils already started after only four days had elapsed; this may be attributed to the stage-specificity of the apple blossom weevil, i. e. the difference in susceptibility to the applied poisons, although primarily to the difference in the migration activity of young and old weevils. It was not established to what extent such factors as weather conditions, varying abundance of foliage or even a repellent effect of the applied insecticides have influence on the varying degree of weevil infestation in the different plots.

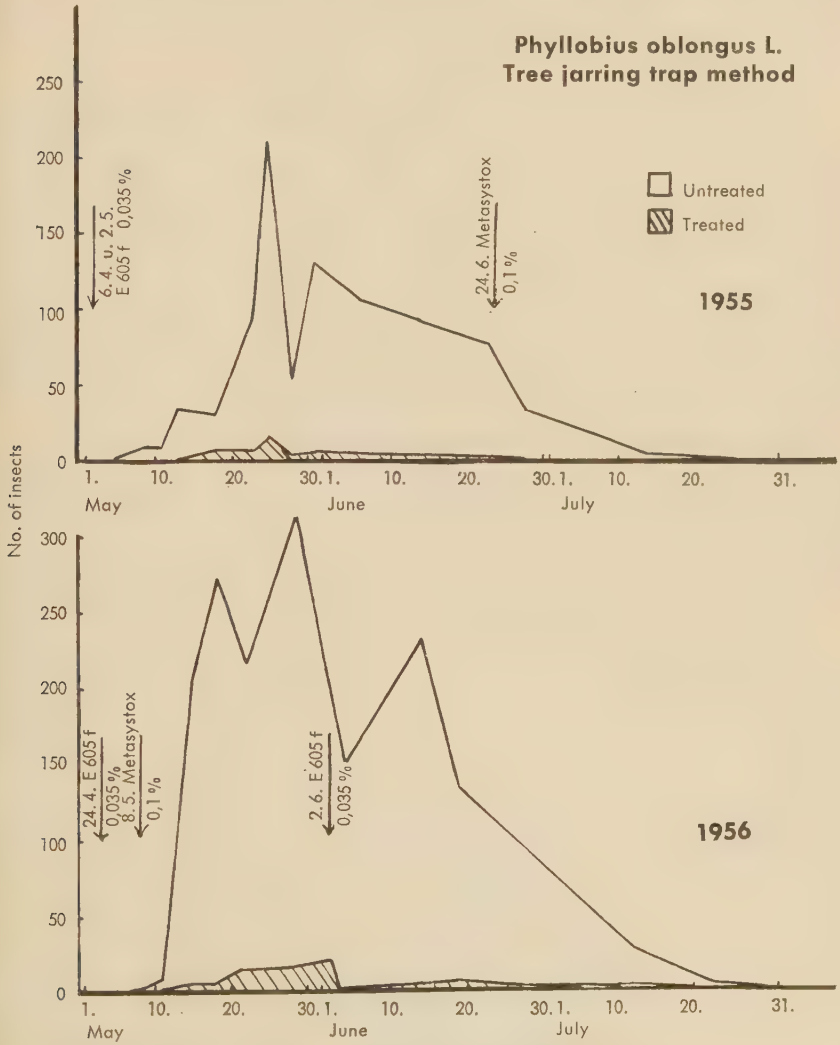


Fig. 10: Population development of *P. oblongus* in 1955 and 1956. (Ordinate: No. of insects trapped on an area of 30 sq. m.)

It is assumed that the apple blossom weevils migrated into the treated section chiefly from the untreated plots which bordered the B-plot in the north-east and south-east.

The pest largely overwintered in the orchard itself; this was revealed by band trap and trunk studies (see P. 225). The oak/hornbeam wood directly adjoining the orchard on the west side and the small allotment of ornamental plants bordering the plot on the north-east side appear to be only of secondary importance with respect to the overwintering of apple blossom weevils and the migration of this pest into the test plot.

The varying numbers of weevils trapped in the two test plots correspond to the different figures recorded for blossom infestation (see P. 197).

Phyllobius oblongus L.

The population development of *P. oblongus* in 1955 and 1956 is plotted in Fig. 10.

The migration of the brown leaf weevil from the overwintering quarters to the test plot started at the same time in both years, namely in the first week of May. The peak of its occurrence was reached at the end of May; by mid-July, the weevils had practically disappeared again from the trees. It is noticeable that the population density in the treated plot is small compared with the untreated check. Migration from the neighbouring untreated plots appears to be very slight. It cannot be said to what extent this is due to the toxic effect of the pre-blossom applications of insecticidal sprays (FOLIDOL-E 605 forte and METASYSTOX) and the slight flying activity of the weevils, or perhaps even to the varying disposition of the test trees.

Another possible cause is that the applied insecticides have a repellent effect on *P. oblongus* brought about by their odour or taste; after all, Ohnesorge (1953) established that several organic acids and aldehydes have a repellent effect on *Hypolobius abietis* L.

Table 15: Caterpillar species registered in the test site at Höfchen during the vegetation seasons of 1955 and 1956, and the frequency of their occurrence in the untreated plot.

		Occurrence in U = untreated B = treated		Frequency of occurrence in U = plot
Macrolepidoptera				
Geometridae:	*Cheimatobia brumata* L.	U	B	xxxx
	Cheimatobia boreata Hb.	U	B	xx
	Hibernia defoliaria Cl.	U	B	xxx
	Hibernia aurantiaria Hbn.	U	B	xx
	Hibernia marginaria F.	U	B	xx
	Boarmia gemmaria Brahm	U	B	xx
	Boarmia consortaria F.	U	B	xxx
	Chloroclistis rectangulata L.	U	B	xxx
	Biston pomonarius Hb.	U	B	xx
	Phigalia pedaria F.	U	B	x

		Occurrence in U = untreated B = treated		Frequency of occurrence in U = plot
Noctuidae:	*Calymnia pyralina* View.	U	B	xxx
	Calymnia trapezina L.	U	B	x
	Calymnia affinis L.	U	B	x
	Scopelosoma satellitia L.	U	B	xx
	Amphipyra pyramidae L.	U	B	xx
	Brachyonycha sphinx	U	B	x
Nolidae:	*Nola cuculatella L.*	U		xx
Lymantriidae:	*Orgya antiqua* L.	U		xx
Bombycidae:	*Malacosoma neustria* L.	U	B	x
Microlepidoptera				
Tortricidae:	*Olothreuthes variegana* Hb.	U	B	xxx
	Tmetocera ocellana L.	U	B	xx
	Capua reticulana Hb.	U	B	xx
	Pandemis ribeana Hb.	U	B	xxx
	Pandemis heparana Schiff.	U	B	xx
	Pandemis corylana F.	U	B	x
	Cacoecia podana Scop.	U		xx
	Cacoecia podana ab. sauberiana	U		x
	Cacoecia crataegana Hb.	U	B	xx
	Cacoecia xylosteana L.	U		xx
	Cacoecia rosana L.	U		x
	Tortrix viridana L.	U	B	xx
	Tortrix wahlbomiana L.	U		xx
	Acalla holmiana L.	U	B	x
	Acalla lipsana Schiff.	U		x
	Ancylis achatana F.	U		xx
	Carpocapsa pomonella L.	U	B	x
Tineoidae:	*Hyponomeuta malinella* Zell.	U	B	xxxx
	Coleophora hemerobiella Sc.	U		xx
	Coleophora nigricella Steph.	U		xx
	Chimabacche phryganella Hb.	U		x

Key to signs in Table 15:

x = isolated occurrence
xx = slight occurrence
xxx = medium occurrence
xxxx = frequent occurrence

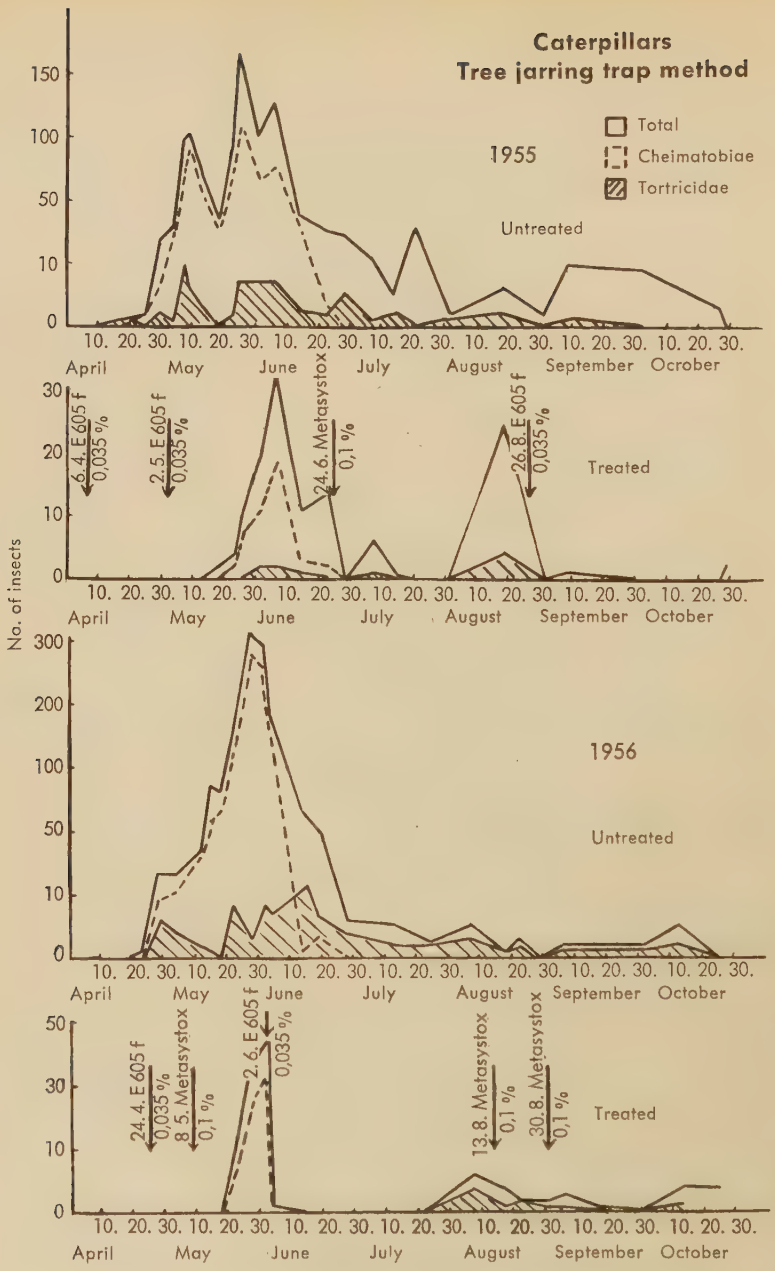


Fig. 11: Caterpillars on treated and untreated trees during the vegetation seasons of 1955 and 1956. (Ordinate: No. of caterpillars trapped on an area of 30 sq. m. Abscissa: Time)

Caterpillars

The caterpillar species that colonized the apple tree of the B-(treated) and U-(untreated) plots, and which were caught and registered by means of the tree jarring trap method are listed above; details are also given on the frequency of their occurrence in the U-plot.

Although only few caterpillar species occurred frequently or on a medium scale as individuals (*Cheimatobia brumata* L., *Hibernia defoliaria* Cl., *Boarmia consortaria* F., *Chloroclistis rectangulata* L., *Calymnia pyralina* View., *Olothreutes variegana* Hb., *Pandemis ribeana* Hb., *Hyponomeuta malinella* Zell.) whereas the majority of them caused only slight or isolated infestation, it cannot nevertheless be denied that caterpillars, taken on the whole, attach certain economic importance. Regular destruction of the assimilating leaf surfaces may result in the vitality of the apple trees being considerably lowered, thus decisively affecting the momentary and subsequent fruit setting.

On studying the caterpillar curves (Fig. 11), one at once recognizes the large difference in the infestation of the treated and the untreated plot. (*Cheimatobia brumata* and *Tortricidae* are plotted separately). In both years, far fewer caterpillars were found in the treated plot than in the untreated check.

Fig. 12: Treated plot

Fig. 13: Untreated plot

Test results 1955

The slight occurrence of caterpillars in the treated plot (see overwintering stages, Page 191), and the high degree of susceptibility of the caterpillars to the applied sprays explain why the first living caterpillars were observed in the B-plot four weeks later than in the U-plot. It is noticeable that the population density increased considerably at the end of May and in early August. The increase in early August was in fact greater than in the untreated plot, and in mid-August four times as many caterpillars were counted in the B-plot as in the U-plot.

The application of METASYSTOX on June 24 and of FOLIDOL-E 605 forte on August 28 suppressed caterpillar infestation in the sprayed area for about two weeks.

Test results 1956

Just as in the previous year, the first caterpillars were observed in the treated plot four weeks later than in the untreated check. It is again noticeable that the population suddenly increased in the middle of May.

An application of FOLIDOL-E 605 on June 2 kept the plot free of infestation for seven weeks. The slight increase of population in early August soon led to an equal infestation density in both test plots.

The caterpillars appear, therefore, to be extremely susceptible to both FOLIDOL-E 605 forte and METASYSTOX. In view of this, it is hardly possible for a plot to be re-populated by pests that may have survived the application and are still present in the stock. So that when increased infestation was nevertheless observed in the treated plot, this may be attributed to wind drift, as also established by Soenen (1951). It was in fact observed that re-colonization by caterpillars usually started following very windy days. It was also established that those trees growing nearest to the untreated plot or to the oak/hornbeam wood bordering on the orchard, were the most severely infested.

By studying the tabulated records for the numbers of insects that were caught by the trap method, it is by no means difficult to form an idea of the immense amount of foliage that must be destroyed in a year by caterpillars alone.

The two photographs taken on June 20, 1956, and reproduced in Figs. 12 and 13, illustrate the outcome of pest control and the failure to carry out controls.

Out of the beneficial insect group, a large number of *Heteroptera, Coleoptera, Neuroptera, Dermaptera* and *Araneidae* were caught by means of the tree jarring trap method.

Heteroptera

The population development of Heteroptera is plotted in Fig. 14. Consideration was given only to those bug species occurring the most frequently in this apple plot. Of these 22 bug species (Table 16), 90 % can be termed as being predaceous and thus graded as beneficial insects, as based on data published in the pertinent literature, and on the results of the author's own studies.

For the purpose of the graph, a logarithmic graduation was selected in order to give adequate prominence to the range between 1 and 10. The diffe-

rent points of the curves correspond to the average numbers of *Heteroptera* (larvae and adults) trapped per area of 3 square metres and per plot.

It is evident from the curves that *Heteroptera* colonized the trees in more or less abundant numbers throughout the vegetation season. Two peaks at the end of June and in late August are clearly perceptible in both years. The curves show the normal population development in the untreated plot as compared with a greatly changed cycle of population development in the treated plot brought about by the application of pesticide. Equal population densities in both test plots were observed only at the beginning of the vegetation season

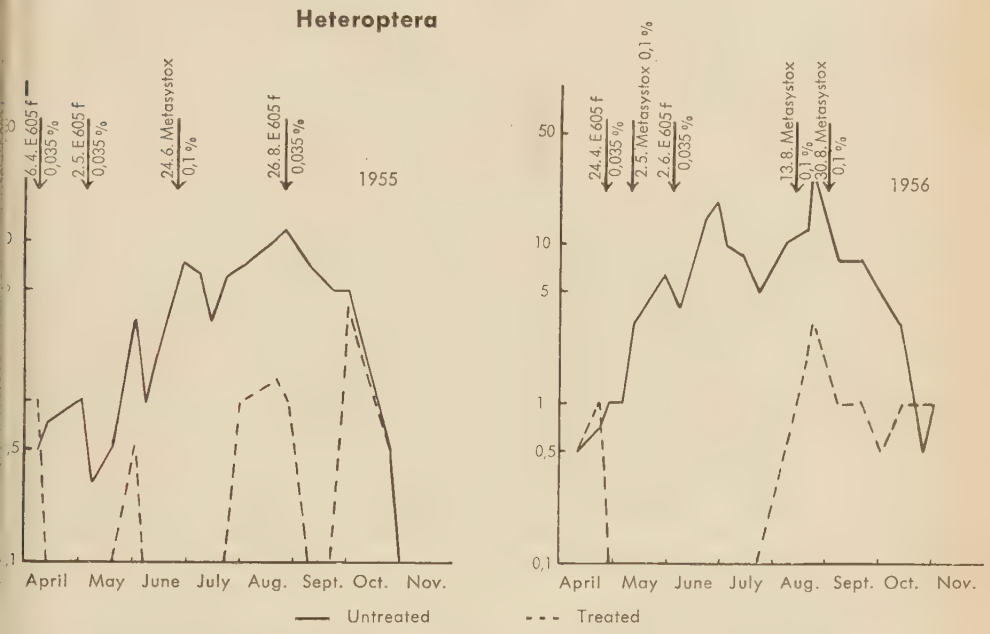


Fig. 14: Population development of *Heteroptera* in 1955 and 1956. (Ordinate: No. of insects – adults and larvae — trapped on area of 3 sq. m.)

before applications of pesticide had been carried out at all, and at the end of the vegetation season at a time when the spray applications had long been completed. During the growing season, however, the numbers of insects caught in the treated plot were negligible compared with the figures recorded for the untreated plot.

It is obvious that FOLIDOL-E605 forte, regardless of whether it was sprayed in spring or in late summer, caused greater decimation of the *Heteroptera* fauna than did METASYSTOX, but just the same re-colonization started at the latest three weeks after the application also when FOLIDOL-E605 forte was used.

Table 16: Tests on feeding of *Heteroptera* with harmful insects

Family	Subfamily	Genus	Insects used for feeding: *Metatetranychus ulmi*	*Aphididae*	*Eriosomatidae*	caterpillars and others
			x = positive — = negative			
Miridae	*Mirinae*	*Phytocoris tiliae* Fabr.	x	—	—	—
		Phytocoris dimidiatus Kb.	x	—	—	—
		Phytocoris reuteri Saund.	x	—	—	—
		Lygus rugulipennis Popp.	—	—	—	—
		Lygus kalmi L.	—	—	—	—
		Lygus pabulinus L.	—	—	—	—
	Deraeocorinae	*Deraeocoris ruber* L.	x	x	—	x
	Orthotylinae	*Blepharidopterus angulatus* Fall.	x	x	—	x
		Malacoris chlorizans Panz.	x	—	x	—
		Orthotylus marginalis Reut.	x	—	—	—
		Pilophorus perplexus D. a. S.	x	—	x	—
	Plagiognathinae	*Psallus ambiguus* Fall.	x	x	—	x
		Atroctomus mali M.-D.	x	x	x	x
	Diciphinae	*Campyloneura virgula* H.-S.	x	—	—	—
Anthocoridae						
	Anthocorinae	*Anthocoris nemorum* L.	x	x	—	x
		Anthocoris nemoralis F.	x	x	—	—
		Anthocoris confusus Reut.	x	—	—	—
		Orius minutus L.	x	x	—	—
		Orius majusculus Reut.	x	x	—	—
Nabidae		*Nabis apterus* F.	x	x	—	x
		Nabis ferus L.	x	—	—	x
		Nabis pseudoferus Rem.	—	—	—	x

The effect of METASYSTOX, when applied in May and June, could not be checked because the *Heteroptera* fauna had not sufficiently recovered. When applied in late summer, METASYSTOX had no decimating effect at all on *Heteroptera*.

It was not possible to establish with an adequate degree of certainty the extent to which the varying amount of foliage — due to regular cultural measures — has an influence on the varying population density in the different plots.

The recolonization of the treated plot by *Heteroptera* was brought about by migrations from the adjoining untreated plot.

Laboratory foddering experiments (in petri dishes) were carried out with all the *Heteroptera* caught by means of the tree jarring trap method, to test them for their "usefulness". The results of these tests, which largely agree with those published in the pertinent literature (Massee, Collyer, Andersen, Geier and Baggiolini, Geijkos, Liste, Dosse, Steiner, Günthart, Newcomer and Yothers, Wybou) are given in Table 16.

The development of the population of *Anthocoris nemorum* L., one of the most important predaceous *Heteroptera* occurring in Höfchen, is separately plotted in Fig. 15, together with data on the influence of insecticidal chemicals on this insect's population density.

Test results 1955

FOLIDOL-E 605 forte applied on April 6 and May 2, had the effect of keeping the B-plot free of *Anthocoridae* for three weeks after each treatment. An application of METASYSTOX on June 24 appeared, on the other hand, to have little or no influence on the development of *Anthocoridae*. Another application of FOLIDOL-E 605 forte in late summer again resulted in the decimation of *Anthocoridae* so that no members of this family were observed in the treated plot for three weeks after the spray. But the recolonization of the plot at the end of this period was so heavy that by the end of September the population of *Anthocoridae* in the treated plot was even larger than that in the untreated plot.

The sudden increase of the population in the B-plot may perhaps be attributed to the warm, summer-like weather from September 19 to 25, and to the resultant increased migratory activities of *Heteroptera*.

Test results 1956

The population curves for 1956 were similar to those plotted for 1955. Once again, FOLIDOL-E 605 forte had a decimating effect on the population of *Anthocoridae*, whereas METASYSTOX only had a slight influence on the population development of this family.

Summarizing, it may be said that the predaceous *Heteroptera* (adults and larval stages) are only slightly decimated by METASYSTOX, but very severely by FOLIDOL-E 605 forte. This latter product kept the treated plot free of *Heteroptera* for at least three weeks, and at the most for six weeks.

The marked increase of the *Heteroptera* population first observed in late autumn in the treated plot, may be primarily attributed to the fact that the toxic effect of the applied sprays lessened at this particular time. Better feeding conditions, i. e. fresher and healthier foliage on the trees brought about by regular cultural measures, and the abundance of predators (spider mites) in the B-plot, appeared to be factors of only secondary importance in this case, otherwise a much greater migration from the untreated plot ought to have taken place.

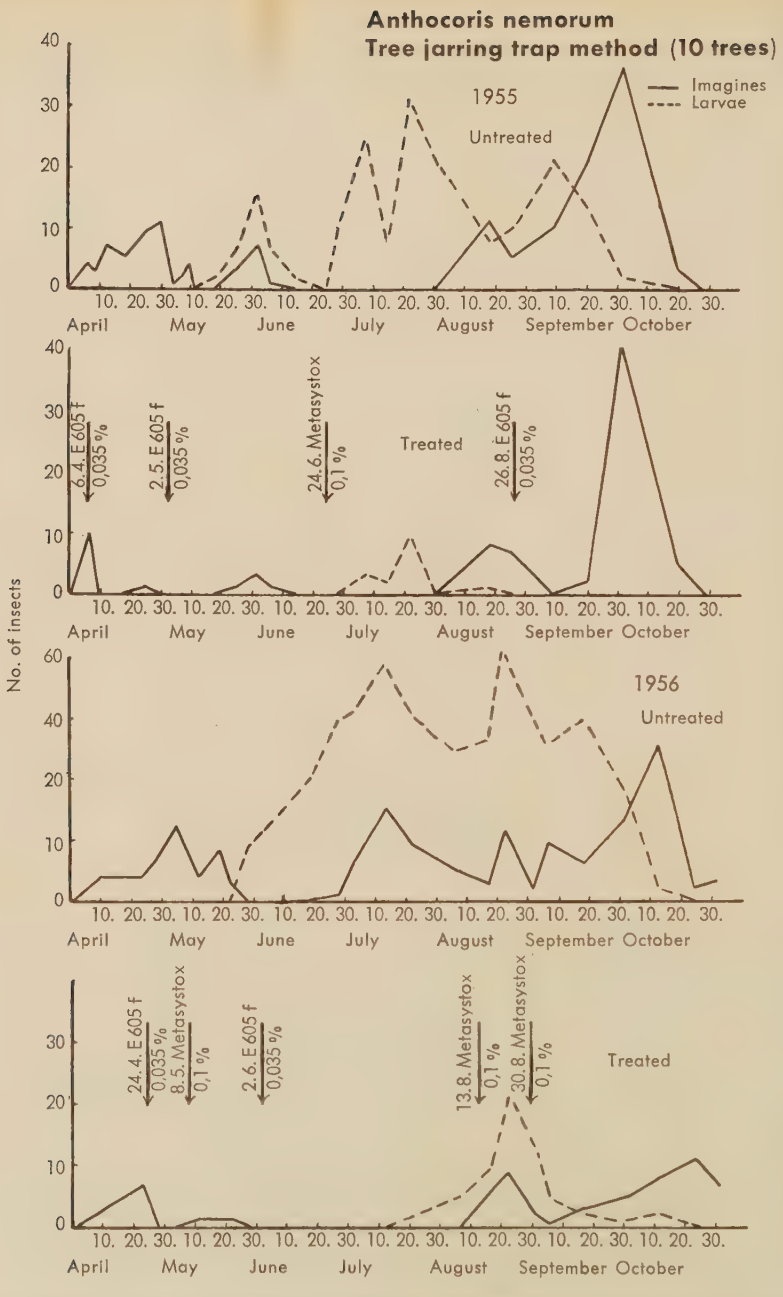


Fig. 15: Population development of *Anthocoris nemorum* L. in 1955 and 1956. (Ordinate: No. of insects trapped on area of 30 sq. m. Abscissa: Time)

The almost equal results for the numbers of *Heteroptera* trapped in autumn, 1955 in the B- and U-plots corresponded to similar results for insects trapped by the corrugated paper band method in the following winter (see P. 227).

It was noticed that the applied insecticides also adversely influenced the population development of other beneficial insects such as *Coccinellidae Cantharidae, Cleridae, Staphilinidae, Mecoptera, Neuroptera* (only larvae), *Syrphidae* etc. Their larvae were completely eradicated in every case, although the more active imagines were observed again in the treated plot at the latest three to four weeks after the application, even though only in small numbers.

Outstanding among these results are the more or less equally high numbers of *Dermaptera* trapped in the B- and U-plots, and the larger numbers of *Neuroptera* (imagines) (see also P. 219) and *Opilionidae* caught in the B-plot.

Dermaptera, Opilionidae and *Araneidae* proved to be only slightly susceptible to the applied poisons, this being primarily due to their concealed and predominantly nocturnal mode of life.

Fig. 16: Bait jar

4. Bait jar and yellow pan traps

These two trap methods were adopted not only during the vegetation season but also in the winter months when the weather permitted.

Bait jar traps

For this purpose, use was made of medium-sized jam jars which were filled with a solution of apple juice and sugar (1 part of fruit juice, 2 parts of water, 5 lumps of sugar), suspended from branches in the top of the trees (Fig. 16), and checked at regular intervals.

The bait jars proved to be especially attractive to *Lepidoptera, Neuroptera* and *Diptera,* althogh large numbers of *Mercoptera, Psyllidae* and *Hymenoptera (Symphyta* and *Aculeata)* were also sometimes found in the jars. (The bait liquid was renewed every two weeks. *Lepidoptera* and *Neuroptera* were registered daily, and all other species every two weeks.)

The author's special interest was concentrated on *Lepidoptera* and their occurrence in the different test plots. A determination of all *Lepidoptera* caught in the bait jars (no consideration has been given to *Tineoidae* below) showed that the majority were *Noctuidae,* and usually such species whose caterpillars do not occur on apples so that they cause no damage of economic importance here *(Agrotis pronuba* L., *A. fimbria* L., *A. janthia* Esp., *A. C-nigrum* L., *A. plecta* L., *A. triangulum* Hufm., *A. tritici* L., *Mamestra pisi* L., *Acronycta pisi* L., *A. rumicis* L., *Xanthia fulvago* L., *Plusia gamma* L., *Leucania pallens* L., *L. l-album* L., *Trigonophora meticulosa* L., *Scopelosoma satellitia* L., and others).

These were followed in order of abundance by the more or less noxious *Tortricidae, Sesiidae, Hyponomeutidae, Geometridae* and *Nolidae.*

Table 17: Total nos. of beneficial insects trapped on an area of 30 sq. m. in the vegetation seasons of 1955 and 1956.

	1955		1956	
	untreated	treated	untreated	treated
Coccinellidae (imagines)	123	42	84	16
Coccinellidae (larvae)	81	8	74	0
Cantharidae	16	2	7	1
Tachiporus (Staph.)	15	7	18	6
Carabidae	0	0	4	2
Dermaptera	56	51	46	39
Neuroptera (imagines)	2	7	6	10
Neuroptera (larvae)	79	50	115	64
Syrphidae (imagines)	2	3	6	2
Syrphidae (larvae)	51	5	18	6
Opilionidae	7	12	3	17

All the *Lepidoptera* species caught by means of the bait jar method, and which belong to the actual fruit tree biocoenosis — in other words all those species whose juvenile stages also occur on apples — are listed in the following table:

Table 18: Lepidoptera occurring in the test area at Höfchen, 1955 and 1956.

Tortricidae	*Olothreuthes variegana* Hb.
	Tmetocera ocellana L.
	Pandemis ribeana Hb.
	Pandemis ribeana ab.ceresana Hb.
	Pandemis heparana Schiff.
	Pandemis corylana F.
	Cacoecia podana Scop.
	Cacoecia podana ab. sauberina
	Cacoecia crateaegana Hb.
	Cacoecia xylosteana L.
	Cacoecia rosana L.
	Tortrix viridana L.
	Tortrix wahlbomiana L.
	Acalla holmiana L.
	Acalla lipsana Schiff.
	Ancylis achatana F.
	Capua reticulana Hb.
	Carpocapsa pomonella L.
Sesiidae	*Trochilium myopiforme* Bkh.
	Trochilium vespiforme L.
Geometridae	*Chloroclistis rectangulata* L.
	Hibernia leucophaeria Schiff.
	Hibernia marginaria F.
	Phigalia pedaria F.
	Boarmia consortaria F.
	Ennomos quercinaria Hufn.
	Hibernia aurantiaria Hbn.
	Biston betularia L.
	Biston pomonarius Hb.
	Larentia siterata Hufn.
Noctuidae	*Calymnia pyralina* V.
	Calymnia trapezina L.
	Calymnia affinis L.
	Scopelosoma satellitia L.
	Brachyonycha sphinx. Hufn.
	Amphipyra pyramidea L.
Nolidae	*Nola cucullatella* L.
Lymantridae	*Orgya antiqua* L.

Of course, it was not possible to catch all the *Lepidoptera* species occurring in the orchard, by means of the bait jar method; this was prevented by the varying susceptibility of the different species to lures.

Out of the 18 *Tortricidae* species found in the bait jars, *Olothreutes variegana* Hb. and *Pandemis ribeana* Hb. were the most abundant.

Carpocapsa pomonella was completely lacking in the test plots, although rather large numbers of this species were found in bait jars set out in the old adjoining tree stand which is also part of the research centre.

Only few *Rhopalocera* (day moths) were found, except during a period of heavy migration of *Pyrameis atalanta* L. in autumn, 1955.

In the application of bait methods and the evaluation of test results — the same applies to light traps — consideration must, of course, be given to the following. The numbers of insects caught in the two test plots cannot be brought into relation to a given unit of space or area, in other words only to the respective plot, but rathermore to an area of unknown size in which the moths were concentrated at certain luring points (4 bait jars per plot). Differences of species could not, therefore, be established in the different test plots. The total numbers of insects trapped per bait jar in the different plots are given in Table 19.

Table 19: Total nos. of *Lepidoptera* (imagines) trapped, 1955—1956.

Lepidoptera		Average nos. caught per bait jar 1955 untreated	1955 treated	1956 untreated	1956 treated
a) noxious:					
	Tortricidae	92	89	63	56
	Noctuidae	7	6	5	5
	Geometridae etc.	31	26	14	17
		130	121	82	78
b) neutral:					
	Noctuidae	361	574	282	349
	Geometridae	6	14	5	4
	Rhopalocera	5	8	1	—
		372	596	288	353
	Total:	502	717	370	431

A surprising feature of these results was that the total numbers of *Lepidoptera* trapped in the B-plot were so high. However, on dividing up the moths into noxious and neutral species, it was found that only neutral *Lepidoptera*, in particular *Noctuidae*, were more abundant in the treated plot, whereas approximately equal numbers of noxious species were counted in both plots.

The fact that the numbers of *Lepidoptera* caught in the treated plot were higher or at least equal to those recorded for the untreated plot, despite

application of insecticidal chemicals, must be primarily attributed to the attractiveness of the bait, and to the movements of the moths. But there can be no doubt that a part is played in this by such other factors as the denser growth of foliage indirectly connected with the cultural measures carried out, and the natural attractiveness to the partly heliophob moths, the greater protection offered by the location and the presence of aphis excrement in late autumn. The possibility must not be ruled out, either, that the applied insecticides had a certain luring effect on the *Lepidoptera*.

The flight of the moths within the two test plots is plotted in Fig. 17. The average numbers trapped per bait jar (including all moths) are entered on the ordinate, and the time factor is entered on the abscissa. The numbers of moths trapped were combined for six-day periods to illustrate the progress of moth flight, and the corresponding mean temperatures and amounts of rainfall were calculated to depict the weather conditions.

The curves show that *Lepidoptera* were present in the apple orchard throughout the year. Even in the coldest months (January and February) some moths *(Scopelosoma satellitia)* were always found in the bait jars. It was observed that the main flight period, in other words the period when the largest numbers were attracted to the jars, was from June to September.

The fluctuations of the curves are primarily due to weather influences. Low temperatures and heavy rainfall checked moth flight.

Control measures, on the other hand, appeared to have only slight influence on the moth flight. Any disturbing effects caused by applications of insecticides had been compensated for at the latest one week after the spray, and even earlier in most cases.

Apart from being very attractive to *Lepidoptera*, the bait jars also lured large numbers of *Chrysopidae, Hemerobiidae, Mecoptera, Psyllidae, Symphyta* and *Terebranta*. They proved to be very suitable for trapping the more or less important *Diptera*.

Fig. 18 illustrates the population development of *Chrysopidae*, and the influence exerted upon this development by climatic factors and insecticidal chemicals.

The numbers of green lacewings trapped were combined for five-day periods to illustrate the progress of flight, and the corresponding mean temperatures and amounts of rainfall were calculated to depict the prevailing weather conditions.

The climatic factors appear to be mainly responsible for the marked fluctuations of the flight curves. Chemical controls, on the other hand, had only little influence on the course of the *Chrysopidae* curve, and in fact none whatsoever in the summer months.

It is noticed that the population curves plotted for the treated section rise well above those plotted for the untreated check, from late July onwards.

The increased migratory flight of *Chrysopidae* to the B-plot may be accounted for on the one hand by the more dense and healthier foliage of the cultivated trees and the resultant greater attractiveness to *Neuroptera* some of which prefer shade (Stitz, 1931), and on the other hand to the greater protection offered by the treated plot as compared with the untreated check.

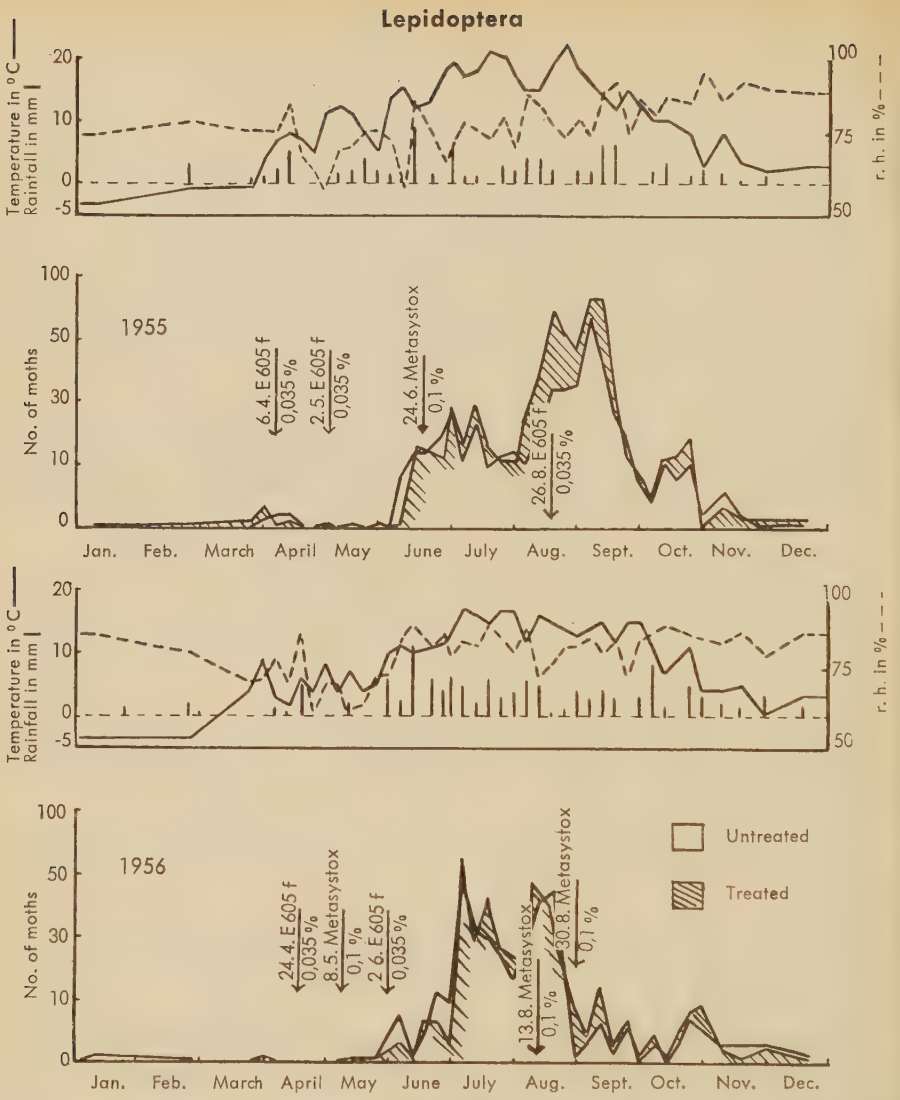

Lepidoptera
Temperature in °C
Rainfall in mm
r. h. in %
1955
No. of moths
6.4. E 605 f 0,035 %
2.5. E 605 f 0,035 %
24.6. Metasystox 0,1 %
26.8. E 605 f 0,035 %
Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.
1956
24.4. E 605 f 0,035 %
8.5. Metasystox 0,1 %
2.6. E 605 f 0,035 %
13.8. Metasystox 0,1 %
30.8. Metasystox 0,1 %
Untreated
Treated

Fig. 17: *Lepidoptera* flight in the treated and untreated plots, 1955 and 1956. (Ordinate: No. of moth per bait jar. Abscissa: Time)

It cannot be said to what extent the large amount of food offered in the way of spider mites and aphids (latter from September onwards; see P. 193) also had bearing on the attractiveness of the plot to *Chrysopidae*.

The differences in the numbers of *Chrysopidae* caught in the two plots are evident from the following table:

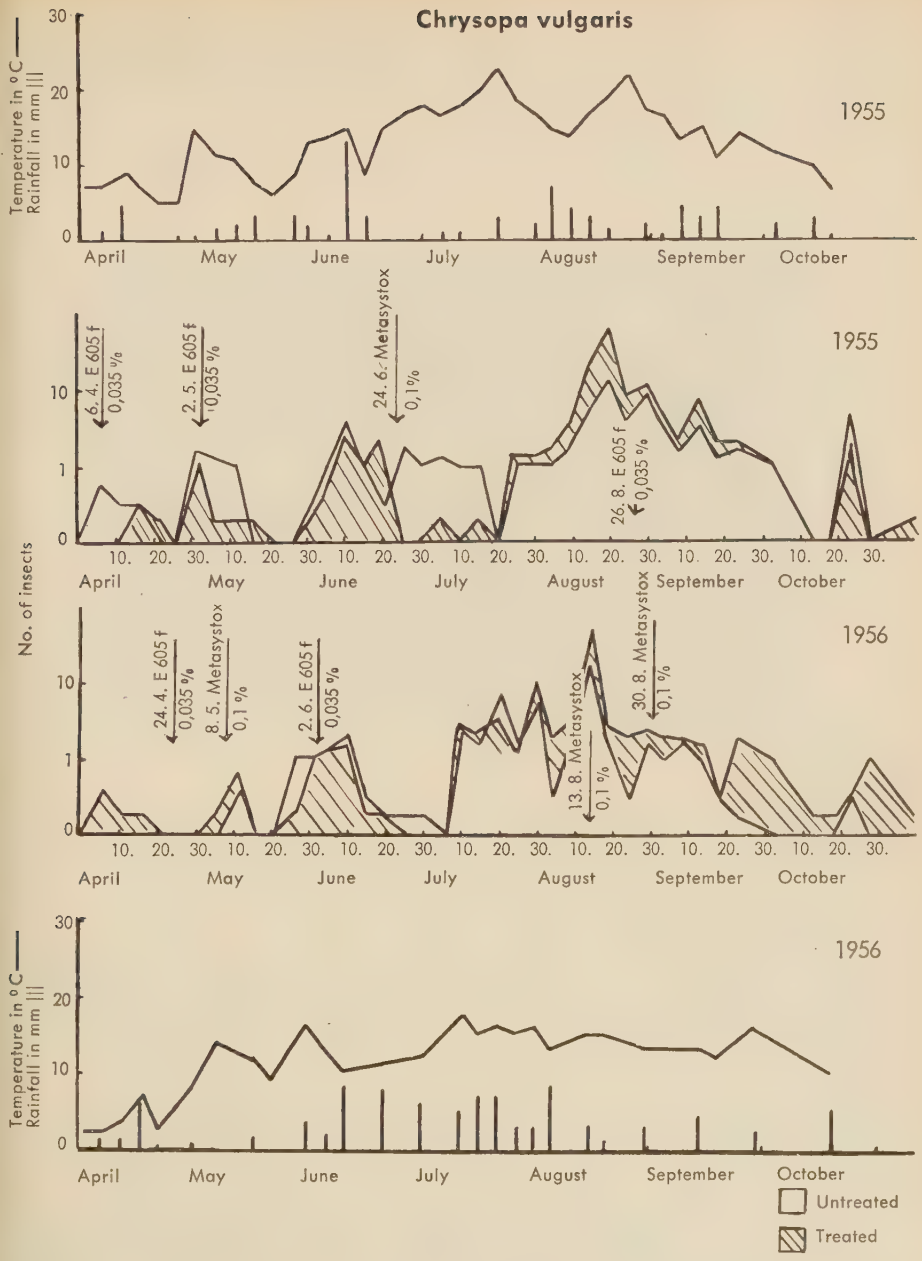


Fig. 18: *Chrysopidae* flight in treated and untreated plots during the vegetation seasons of 1955 and 1956 (Ordinate: No. of insects per bait jar. Abscissa: Time)

Table 20: Nos. of Chrysopidae (imagines) caught in 1955 and 1956.

	Average no. trapped per bait jar (N = 4)	
	1955	1956
untreated	83	55
treated	100	79

The results obtained for *Hemerobiidae* corresponded to those recorded for *Chrysopidae*, namely far more brown lacewings were found in the treated plot than in the untreated check. It was, however, most noticeable that *Mecoptera* and *Cantharidae* — also known as predators of aphids and other small insects — were more abundant in the untreated plot than in the sprayed section (see Table 21). They are apparently more susceptible.

Table 21: Nos. of *Hemerobiidae, Mecoptera* and *Cantharidae* caught in the vegetation seasons of 1955 and 1956.

	Nos. trapped (imagines) per 4 bait jars			
	1955		1956	
	untreated	treated	untreated	treated
Hemerobiidae	12	27	7	15
Mecoptera	36	22	48	31
Cantharidae	15	2	5	2

Yellow pan traps

Working according to the method described by Moericke (1950), tin pans of 22 cm diameter, were coated on the inside with a yellow, weatherproof enamel varnish, filled later with a mixture of water and detergent, and then placed on small wooden platforms in the orchard (see Fig. 19). The pan traps were checked every 7 to 14 days.

The yellow pans proved to be attractive mostly to *Aphidae, Psyllidae* and *Cicadidae*, although *Coleoptera. Syrphidae* and *Hymenoptera* were also caught by this method.

The total numbers of insects caught by this yellow pan trap method in 1955 and 1956 are plotted in Fig. 20. The curves correspond to the average number of insects (except *Aphidae, Psyllidae, Terebrantes* and *Diptera)* taken from the pan traps at regular intervals. Pests and beneficial insects are entered separately. The neutral species were also recorded but they will not be given consideration here.

Just as for the tree jarring trap method (see Fig. 7), the curves for the treated plot show that the development of population density was greatly affected by the application of insecticides. Once again, far more pests than beneficial insects were found in the first half of the vegetation period (see also Table 22), and again the numerical ratio of pest to predator shifted in favour of the beneficial insects in the course of the year.

Fig. 19: Yellow pan trap

Table 22: Yellow pan trap method: Average nos. of pests and beneficial insects trapped in 1955 and 1956 (N = 4).

		Pests untreated	Predators untreated	Pests treated	Predators treated
1955	1st half of year (Jan.—July)	51	19	11	9
	2nd half of year (July—Dec.)	7	57	2	20
	Yearly sum:	58	76	13	29
1956	1st half of year (Jan.—July)	82	19	13	8
	2nd half of year (July—Dec.)	25	50	11	36
	Yearly sum:	107	69	24	44

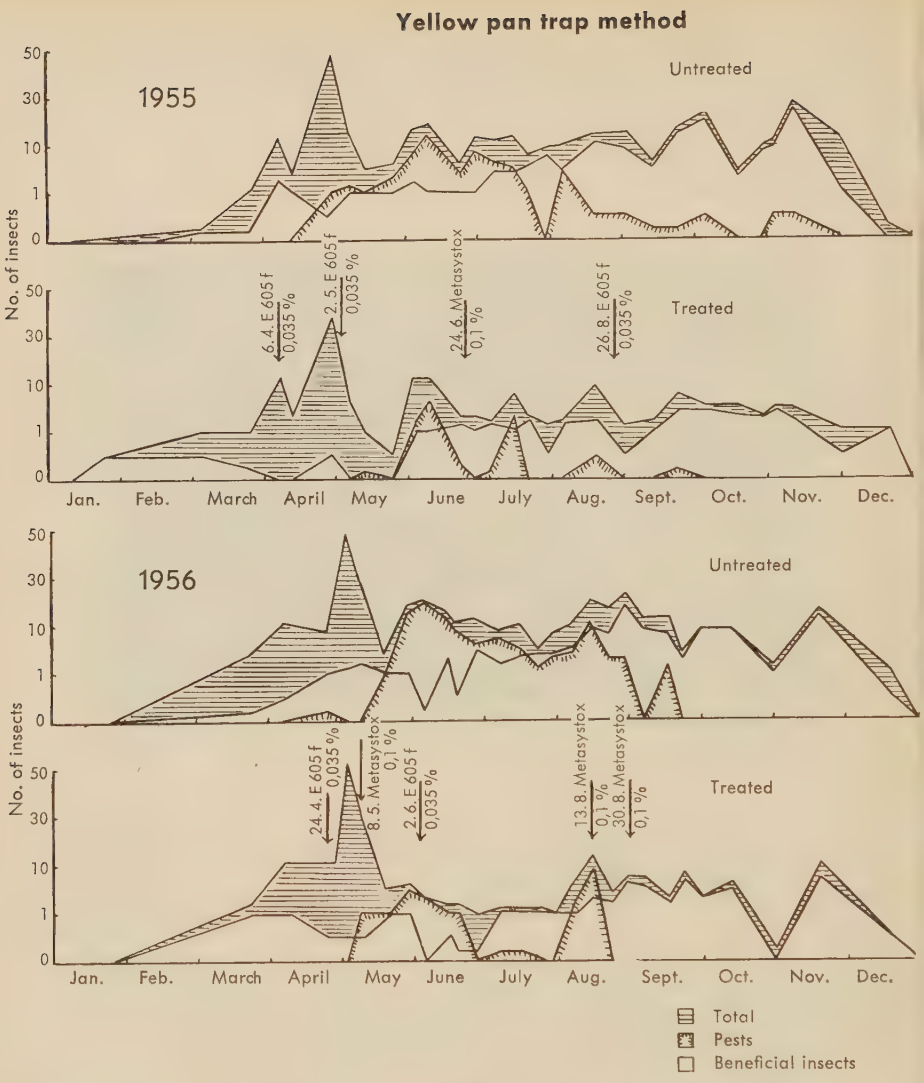


Fig. 20: Total nos. of insects caught by yellow pan trap method in treated and untreated plots, 1955 and 1956, making separate allowance for pests and beneficial insects. (Overall curve = pests + beneficial insects + neutral insects. Ordinate: No. of insects per dish trap. Abscissa: Time)

Table 23 gives the total numbers of *Syrphidae* (imagines) caught in 1955 and 1956. By way comparison, the corresponding values for the bait jar trap method are also given. The striking feature of these data is the relatively slight difference between the treated plot and the untreated check in 1956.

Table 23: Total nos. of *Syrphidae* (imagines) trapped in yellow pans and bait jars in 1955 and 1956.

	1955		1956	
	untreated	treated	untreated	treated
Yellow pans	53	16	128	110
Bait jars	42	29	59	51

5. Sticky band, corrugated paper band and glass traps

In order to determine any differences between the treated plot and the untreated check with respect to infestation by *Cheimatobia brumata* L., ten trees in each plot were provided with sticky bands* in autumn, and checked each day. By this method, it was possible to obtain information not only on the exact dates of the start and end of the moth flight and migration into the plot, but also on the numbers of winter moth that occurred in 1955 and 1956.

In 1955, the first winter moths (both females and males — the latter presumably attracted by the odour of the females) were observed on the sticky bands on November 3, and in the following year on November 5. The migration of moth into the plot had practically come to an end by mid-December in both years. With respect to the commencement and termination of moth migration into the plot, no differences were established between the treated section and the untreated check.

The average numbers of *Cheimatobia brumata* L. trapped in the different test plots are tabulated below:

Table 24: Cheimatobia infestation on treated and untreated trees in autumn 1955 and 1956 (N = 10).

	No. of moths per tree			
	1955		1956	
	untreated	treated	untreated	treated
Males	8	5	3	1
Females	11	6	4	2
Total	19	11	7	3

The tests revealed a) that there was a greater abundance of winter moth in 1955 than 1956 as proved by the counts, b) that infestation was more severe in the untreated plot than in the treated section, and c) that more males than females were observed on the sticky bands in both years.

There were only relatively slight differences between the treated plot and the untreated control with respect to abundance of female winter moth.

* Use was made of sticky bands supplied by Messrs. Schacht, Braunschweig.

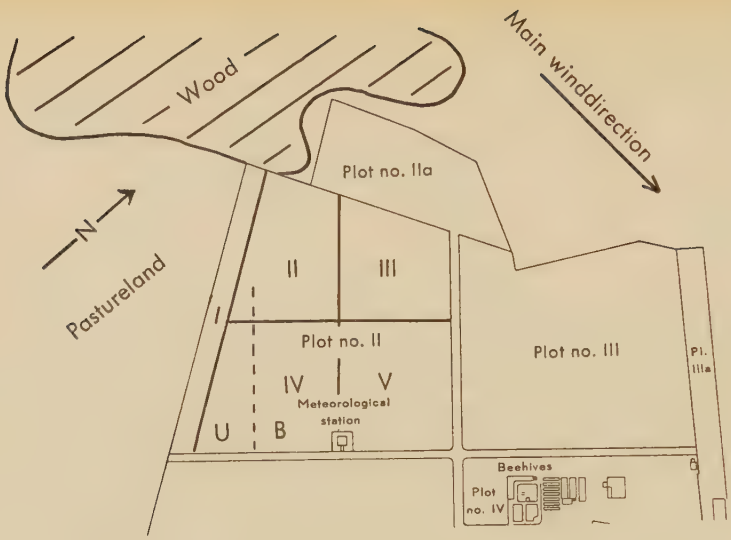


Fig. 21: Test plan: winter moth
Orchard section II/Höfchen (Plot I — plums, plot II to V — apples)

Another factor worthy of mention are the low figures for infestation by adult winter moth (see Table 24) as compared with the high figures recorded for infestation by caterpillars in the preceding spring (see P. 196 and 208).

In order to make a closer study of the question as to what bearing the nearness of an oak/hornbeam wood directly bordering on the orchard, and heavily colonized by winter moth, has on infestation of the test plot by *Cheimatobia,* sticky bands were applied to another 53 trees (45 apple and 8 plum trees, treated and untreated, distributed over the whole of the orchard), and these were checked daily for infestation (see plan in Fig. 21).

Division of the orchard section into five plots, and separation of the apple trees from the plum trees produced the following differences in the density of infestation (Table 25).

Corrugated paper band traps (see Fig. 22), which were applied to the trees of the different plots in late summer and checked several times during

Table 25: Cheimatobia infestation in Section II of the Höfchen orchard autumn 1955 and 1956.

		Average no. of moths per tree					
		1955			1956		
Plot	fruit	males	females	total	males	females	total
I	Plum	28	13	41	11	9	20
II	Apple	14	10	24	6	3	9
III	Apple	12	7	19	4	1	5
IV	Apple	9	6	15	3	2	5
V	Apple	4	2	6	3	1	4

the course of the winter season to establish the rate of infestation by overwintering stages of different insects and *Arachnoidea*, produced the following results:

Table 26: Nos. of insects caught in 10 corrugated paper band traps per plot, in winter of 1955 and 1956.

		untreated	treated
Pests:	*Coleoptera (Anthonomus pomorum)*	175	39
	Lepidoptera (Tortricidae etc.)	24	21
Beneficial insects:	*Heteroptera (Anthocoris nemorum)*	32	31
	Syrphidae (adults and larvae)	16	13
	Dermaptera (Forficula auricularia)	10	26
	Coleoptera (Coccin. and *Staph.)*	4	0
	Hymenoptera (Terebrantes adults)	12	2
	Araneidea	35	39
Neutral insects:	*Coleoptera*	12	6
	Total:	320	177

Fig. 22: Corrugated paper band trap

The numbers of *Lepidoptera, Heteroptera, Syrphidae* and *Arachnoidea* caught by this method were of approximately the same order of magnitude in the treated and the untreated plots. Another feature of these results is that more *Dermaptera* were again trapped in the treated plot than in the untreated control.

Glass traps

For the purpose of registering the fauna populating the soil surface, and of studying the question as to what extent insects crawling on the ground and other arthropods are affected by application of insecticidal chemicals, four glass traps baited with 1 % formaldehyde (see Fig. 23) were placed in the ground in each plot, and checked at intervals of four weeks.

Fig. 23: Glass trap set in ground, protected by cover to keep out rain

The number of glass traps used, however, proved to be inadequate. The numbers of insects etc. caught varied so greatly within the different groups of organisms, also in the treated plot, that they cannot be compared with any degree of reliability.

The glass traps were very suitable for catching *Coleoptera (Carabidae, Staphylinidae* and *Curculinoidae).* But numerous Diptera larvae, caterpillars, *Formicidae, Araneidae, Acaridae, Opilionidae, Diplopodae, Chilopodae, Oligochaetae* and *Mollusca* were also caught by this method.

It does, however, appear that there are no differences between the treated and the untreated plot with respect to the composition of the recorded soil fauna.

6. Leaf controls

Leaf controls were carried out with the object of obtaining data on the development of the spider mite populations in the different test plots.

$4 \times 40 = 160$ leaves were sampled from each plot every week, to check for infestation of mites and eggs. The leaves were taken always from the tops of the same trees, on the north, east, south and west sides; they were then examined under a binocular.

The leaf controls firstly revealed that the composition of the *Acaridae* fauna is completely different in each test plot.

The only phytophagous mites present in both the B-plot and the O-plot were *Metatetranychus ulmi* Koch and members of the meanwhile still economically unimportant *Tydeidae (Brachytydeus sp., Triophtydeus sp.)* and *Tarsonemidae.*

Apart from *M. ulmi,* other species found in the U-plot included *Bryobia praetiosa* Koch (probably introduced by artificial infection in earlier years), *Eotetranychus pomi* Sespargosarian, *Tetranychus urticae* Koch and several species of the *Tarsonemus* and *Eriophyes* genera. The *Brachytydeae* present in the B-plot and O-plot were completely wanting in the U-plot.

The only predaceous mites observed on the leaves in both the B-plot and the O-plot were *Mediolata mali* Ewing and *Typhlodromus tiliae* Oud., but only in very isolated cases and at the beginning and end of the vegetation season. In the U-plot, on the other hand, members of the families of *Raphignatidae (Mediolata mali* Ewing), *Phytoseiidae (Typhlodromus tiliae* Oud., *T. tiliarum* Oud., *T. vitis* Oud. and other *Typhlodromus* species), *Anystidae, Cheyletidae, Bdellidae* and *Trombidiidae* were found throughout the entire vegetation season, although they were most abundant in late summer.

Apart from the differences in the composition of the *Acaridae* fauna, it was also established with the aid of leaf counts that the development of the mite population varied most considerably in the different test plots.

The population development of *Metatetranychus ulmi* Koch is plotted in Figs. 24 and 25 to demonstrate this.

No appreciable differences were established in the population density of *M. ulmi* on the four fruit varieties that were examined — Jonathan, Cox, Oldenburg and Zuccalmaglio — so that the average degree of infestation per plot was determined.

The number of mites and eggs per leaf is entered on the ordinate, and the time factor on the abscissa.

Test results 1955

The infestation density that developed in the U-plot in spring, 1955 was only slight due to the small number of winter eggs laid in the winter months of 1954/55 (see Table 27 and Fig. 5). Furthermore, the population density remained at a relatively low level all through the summer, and only few spider mites were found on the leaves in early September.

The infestation of spider mites in the O-plot was considerably more severe, however. Following up on the large number of winter eggs that were laid (see Table 27), the population density throughout the vegetation season was far greater than in the B-plot and the U-plot (although it remained

greater than the B-plot only up to the beginning of September), and in contrast to the U-plot, spider mites were counted on the leaves in the O-plot until well into October. The five generations that occurred during the vegetation season were clearly distinguishable.

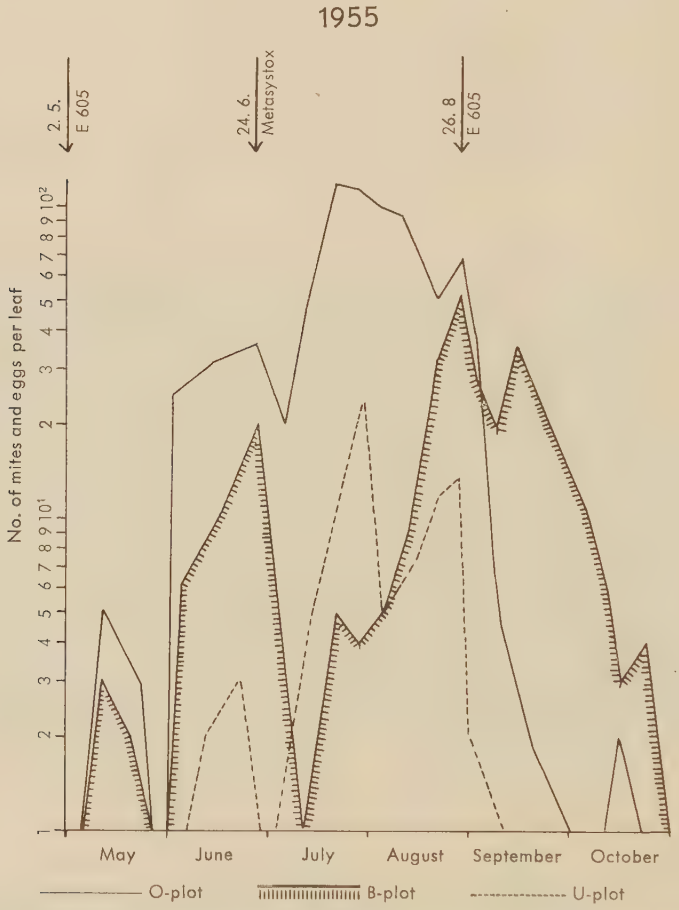


Fig. 24: Population development of *Metatetranychus ulmi* Koch in the different test plots during the vegetation season of 1955. (Ordinate: No. of mites and eggs per leaf; Abscissa: Time)

In the B-plot, on the other hand, it was only with difficulty that the different generations of *M. ulmi* could be distinguished from each other. The entire development of the population appeared to have been greatly retarded as compared with the other two plots. Laying of summer eggs started about two weeks later (June 8) than in the U-plot and O-plot. The population density did not reach its peak until the end of August, in other words about one

month later than in the other plots. The autumn decrease in population density also took place much later, and proceeded at a far slower rate than in the plots not treated with insecticides (U-plot and O-plot). Spider mites were still found on the leaves of the B-plot in November.

FOLIDOL-E 605 forte, applied on May 2 and August 26, had little influence on the development of the spider mite population. A spray application of METASYSTOX carried out on June 24, however, completely eradicated all postembryonic stages, and a renewed increase of the population was not observed until four weeks later.

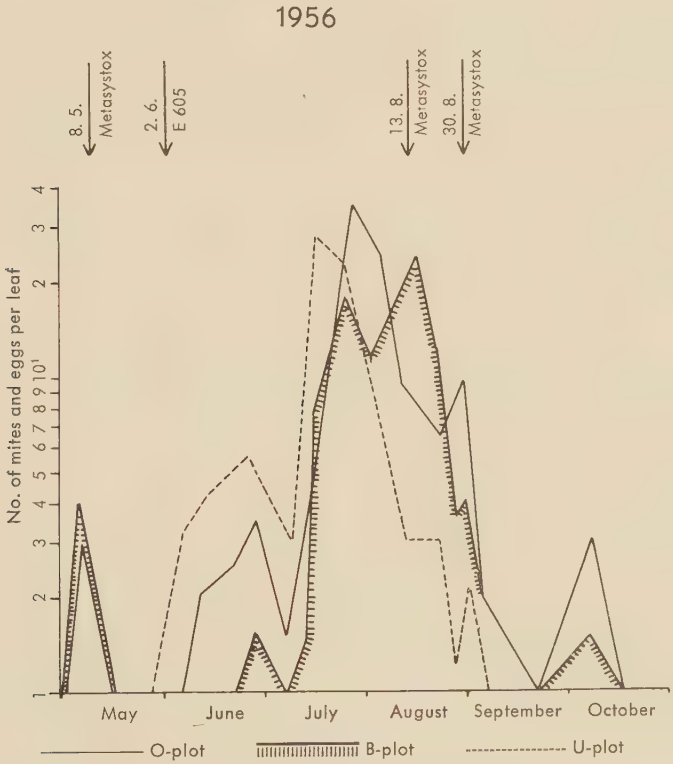


Fig. 25: Population development of *Metatetranychus ulmi* Koch in the different test plots during the vegetation season of 1956. (Ordinate: No. of mites and eggs per leaf; Abscissa: Time)

Test results 1956

The spider mite curve plotted for the U-plot in 1956 is similar to that obtained on the basis of the 1955 results. The curve for the O-plot must be looked upon as having been plotted for a plot treated with insecticides because heavy spray drift on May 8 rendered the plot unsuitable for further studies.

The 1956 spider mite curve for the B-plot provides a completely different picture from that plotted in 1955, due to the fact that the two insecticides

were applied in the reverse order in 1956. METASYSTOX, applied as a pre-blossom spray on May 8, had a far greater effect on the spider mite population than did the FOLIDOL-E 605 treatment carried out at the same time in the previous year. The plot remained practically free of infestation until early June, and in fact no further mass reproduction was observed during the remainder of the vegetation season. In particular, however, the spray applications of METASYSTOX in spring resulted in the population density of *M. ulmi* being reduced to a level so low as to be of no economic importance, just at the most vital time for the generative and vegetative development of the fruit tree, and especially for the fruit setting of the particular year involved (see Untersenhöfer, 1955). — When sprayed in late summer, METASYSTOX again produced a satisfactory effect against *M. ulmi*.

It could not be established to what extent an application of FOLIDOL-E 605 forte carried out in June, succeeded in suppressing the spider mites because the low population density that persisted until mid-July must be primarily attributed to the earlier METASYSTOX spray applied on May 8.

Laying of summer eggs in 1956 started in the B-plot about three weeks later than in the other test plots (U- and O-plot).

The numbers of winter eggs laid (see also Page 193), which corresponded to the varying spider mite infestation in the different plots, are given in the following table.

Table 27: Nos. of winter eggs laid by *M. ulmi* in 1954—1956.

Year	Eggs: Average infestation density on 1 metre of fruit wood		
	U-plot	O-plot	B-plot
1954/55	330	950	440
1955/56	900	4100	2700
1956/57	170	850	750

The leaf controls showed, therefore, that the development of *M. ulmi* in the U-plot started much later in spring and terminated much earlier in autumn than in the B-plot.

The delayed decrease of population density in the B-plot may be attributed primarily a) to more favourable feeding conditions, b) furthermore to a lack or delayed occurrence of natural enemies, and c) perhaps also to a direct influence on the spider mites by the applied insecticides and fungicides.

a) It was observed, for example, that in September the trees of the B-plot were still covered with dark green, healthy foliage, whereas at this time the foliage in the U-plot had already started to turn yellow and wither.

Leaf fall in the U-plot began two weeks earlier than in the O-plot, and almost four weeks earlier than in the B-plot.

The earlier decrease of spider mite population in the U-plot may, therefore, be attributed mainly to the unfavourable feeding conditions brought about

by the fact that no pest control operations had been carried out, resulting in damage being caused to the trees over many years by insects and fungi.

Kuehnen (1947) also reports on better feeding conditions for *M. ulmi* in cultivated orchards. He bases his assertion on the results of chemical leaf analyses which showed that there was a high oxygen content on cultivated trees. He attributes lower infestation densities in uncultivated gardens also to the presence of *Stereum purpureum*. Similar observations were made by Holloway, Henderson and McBurnie (1942), Osburn and Mathis (1946), Rodriguez and Neiswander (1949), Garman and Kennedy (1949) and Haseman (1957). Post (1957) explains that mass reproduction of spider mites in cultivated orchards is mainly due to regular cultural work such as fertilizing and pruning; he speaks of a certain correlation between severe spider mite infestation and high nitrogen content of the leaves.

b) A further reason for the delayed decrease of population density in the B-plot was undoubtedly the large decimation, and also complete elimination, in parts, of the natural enemies, brought about by the preceding applications of insecticides.

Predaceous mites and predaceous *Heteroptera* are the chief enemies of spider mites at Höfchen.

Fig. 26 illustrates the population development of *M. ulmi* and its most important enemies, as registered in the B- and U-plot.

The curves are, however, comparable only with respect to dynamics but not as far as absolute values go, because they are based on the numbers of *Acaridae* caught per leaf and on the numbers of *Hereroptera* trapped per area of 3 square metres.

A study of the graph at once reveals that there are large differences between the B-plot and the U-plot with regard to infestation. In the B-plot, predaceous *Heteroptera* were found only at the beginning and at the end of the vegetation season, whereas predaceous mites were completely lacking. In the U-plot, on the other hand, *Heteroptera* were present all through the vegetation season (see also P. 201) whereas predaceous mites colonized the trees from June and July onwards, and then only in small numbers.

(Predaceous mites were lacking also in the O-plot, where there was only a small abundance of predaceous *Heteroptera.)*

A direct correlation between *M. ulmi* and its major enemies is not evident from the curves. However, it may be assumed that the population density of spider mites in the U-plot would have been considerably greater if there had been no natural enemies present, and what is more the decrease in population in late summer would certainly have proceeded at a slower rate.

(Berker [1955] reports on similar observations made at Stuttgart-Hohenheim, and especially attributes the earlier and speedier decreases in the population density of *M. ulmi* on unsprayed fruit trees in autumn to the activities of predaceous mites.)

Fig. 27 illustrates the relation of *M. ulmi* to predaceous mites during the vegetation seasons of 1955 and 1956 (U-plot). It is noticeable that the development of the predaceous mite population in spring, at a time when the spider mites cause the chief damage, is a very slow process, and does not reach its peak until autumn.

Apart from the predaceous mites and bugs, there are, however, other predaceous insects such as *Staphilinidae, Coccinellidae, Chrysopa* larvae and *Hemerobius* larvae which attach certain importance for their contribution towards decimating the spider mite population.

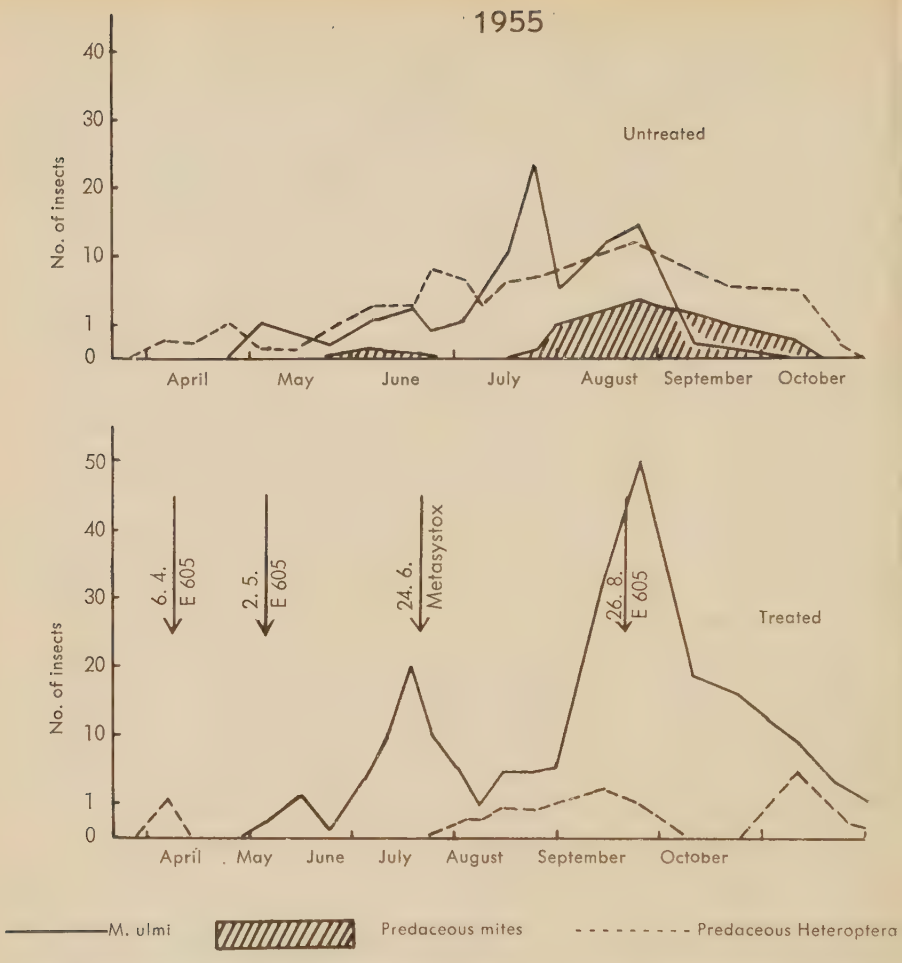


Fig. 26 a: Development of population of *Metatetranychus ulmi* Koch and its major enemies (bugs and predaceous mites) in the vegetation period of 1955. (Ordinate: No. of mites per leaf, no. of bugs trapped per area of 3 sq. m. Abscissa: Time)

All these beneficial insects, especially the predaceous mites, not only have a decisive influence on the current spider mite population, but also primarily on the one to be expected in the forthcoming year. Due to lack of food, the predaceous insects attack the overwintering quarters of *M. ulmi* in the U-plot at an earlier stage which is thus followed by earlier egg laying — already in September (see P. 194); this means that, in contrast to the B-plot where winter eggs are not laid until a month later, extremely good feeding conditions are available to the predaceous insects in the U-plot at a very early stage. It is not surprising that during the October counts of winter eggs (see P. 193), many

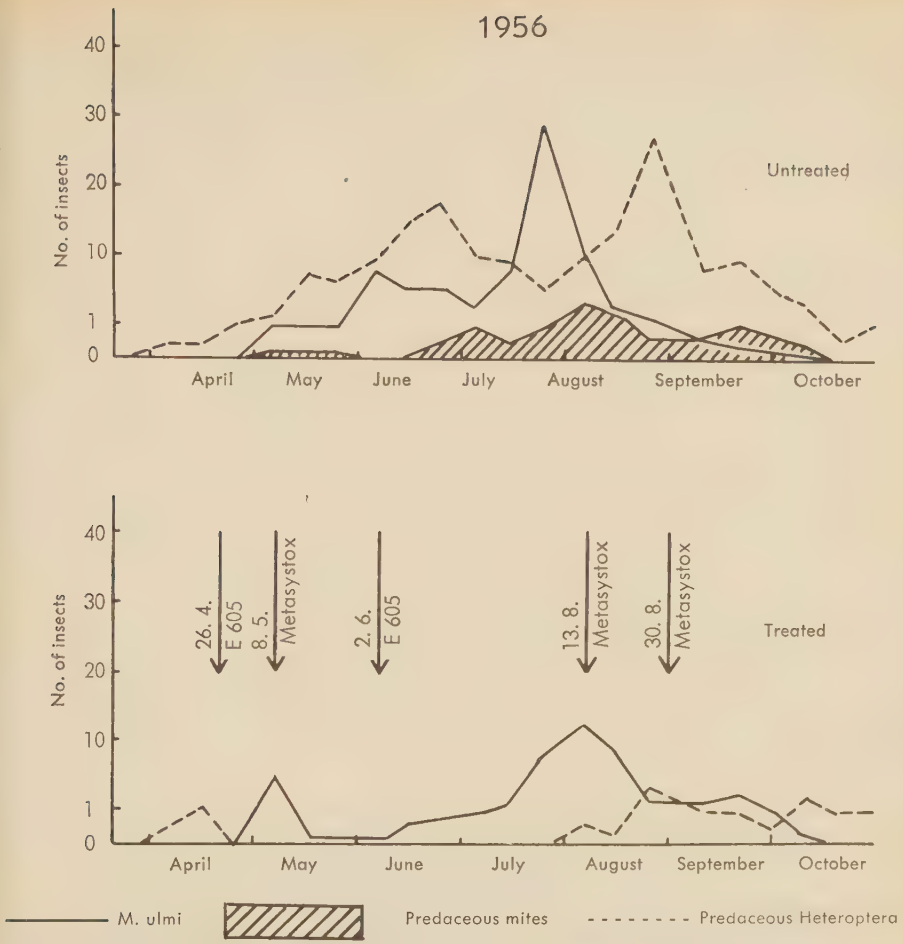


Fig. 26 b: Development of population of *Metatetranychus ulmi* Koch and its major enemies (bugs and predaceous mites) in the vegetation period of 1956. (Ordinate: No. of mites per leaf, no. of bugs trapped per area of 3 sq. m. Abscissa: Time)

more sucked-out spider mite eggs than healthy ones were found in the U-plot. An outstanding fact is that in the O-plot which was sprayed regularly with FOLIDOL-E 605 until 1954, although it is otherwise only treated with fungicides, the predaceous mite fauna has still not recovered even though three years have passed since the applications; it has, however, been observed that the *M. ulmi* population has undergone a considerable increase in this particular plot.

c) No information has yet been published in the literature of the applied pesticides (FOLIDOL-E 605, METASYSTOX, Ob 21 and POMARSOL) having a direct stimulating effect on spider mites, such as has already been established

for dichlorodiphenyl trichloroethane (Hueck, 1953 and Davis, 1952). The possibility cannot, however, be ruled out that the larger spider mite population and bigger number of winter eggs laid in the O-plot, may be attributed to the effect of the above products, in particular the fungicides applied. A direct stimulating effect of both the fungicides and the insecticides on the spider mites immediately after spraying was not, however, observed.

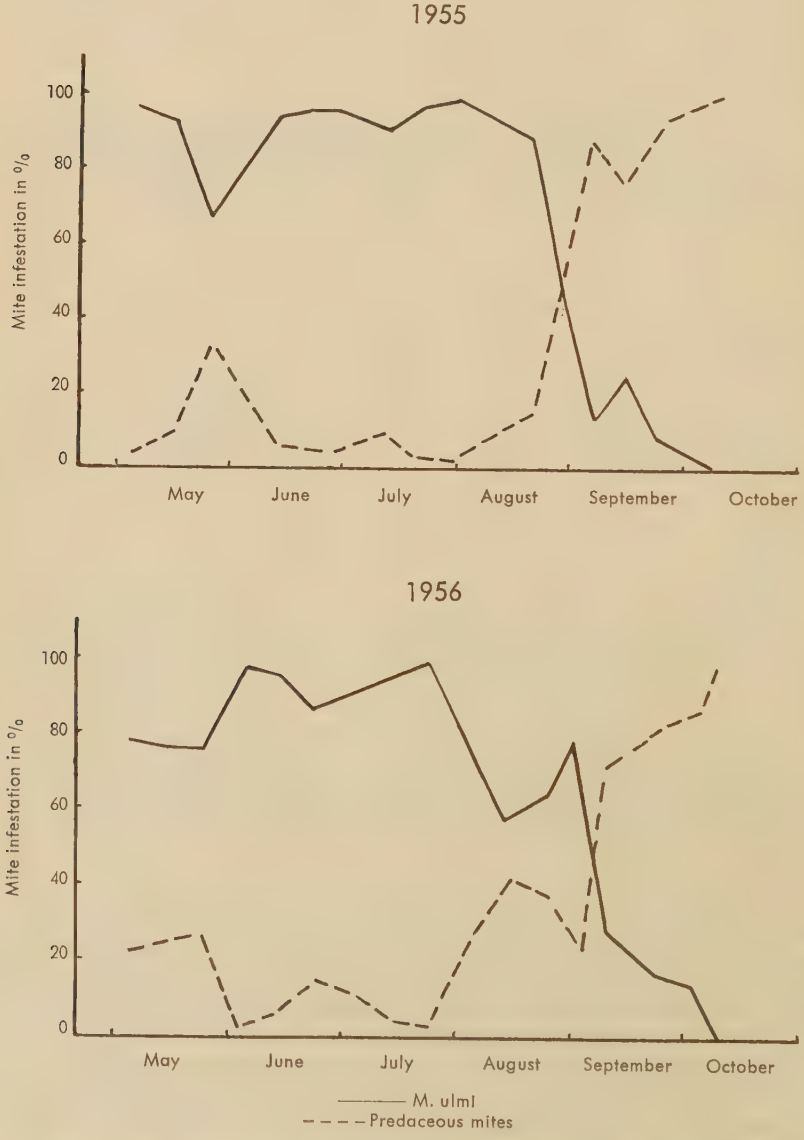


Fig. 27: Ratio of spider mites to predaceous mites in vegetation seasons of 1955 and 1956

To summarize, it may, therefore, be said, that the higher rate of spider mite infestation in the B-plot and O-plot primarily resulted from the applications of pesticides in these plots. Pruning and fertilization undoubtedly had no bearing on the greater population density in this case because after all these cultural measures were carried out with equal efficiency in each test plot.

The higher infestation figures and the delayed decrease in the population density of *M. ulmi* in the B-plot may thus be attributed to the following reasons:

1. Better feeding conditions for the mites, created by regular spray applications (improved foliage: no regular damage by insects and fungi, more favourable chemical composition).
2. Decimation or complete elimination of natural enemies by the applied insecticides, possibly also by fungicides.
3. A possible stimulating influence of the pesticides.

The following reasons may be given for the even greater population density of *M. ulmi* in the O-plot (as compared with the B-plot):

1. Spider mite population not disturbed by insecticidal controls in the last three years.
2. Favourable feeding conditions created by regular spray applications (insecticides only up to 1954), producing healthy foliage.
3. Decimation and elimination of natural enemies by insecticides applied in this plot up to 1954, and perhaps also by the fungicides. Recolonization of the plot by predaceous *Heteroptera, Coleoptera and Neuroptera* larvae was very gradual. The predaceous mite fauna failed to recover from the decimating effects of the pesticides.
4. The applied fungicides possibly had a stimulating effect upon the spider mites.

Fig. 28: Trap sheets

7. Mortality checks immediately after spraying

In a further test conducted to investigate the extent to which the tree top fauna is affected by applications of pesticides, sheets measuring 2×3 square metres were spread out underneath the trees before they were sprayed, in order to catch the insects as they fell to the ground (Fig. 28).

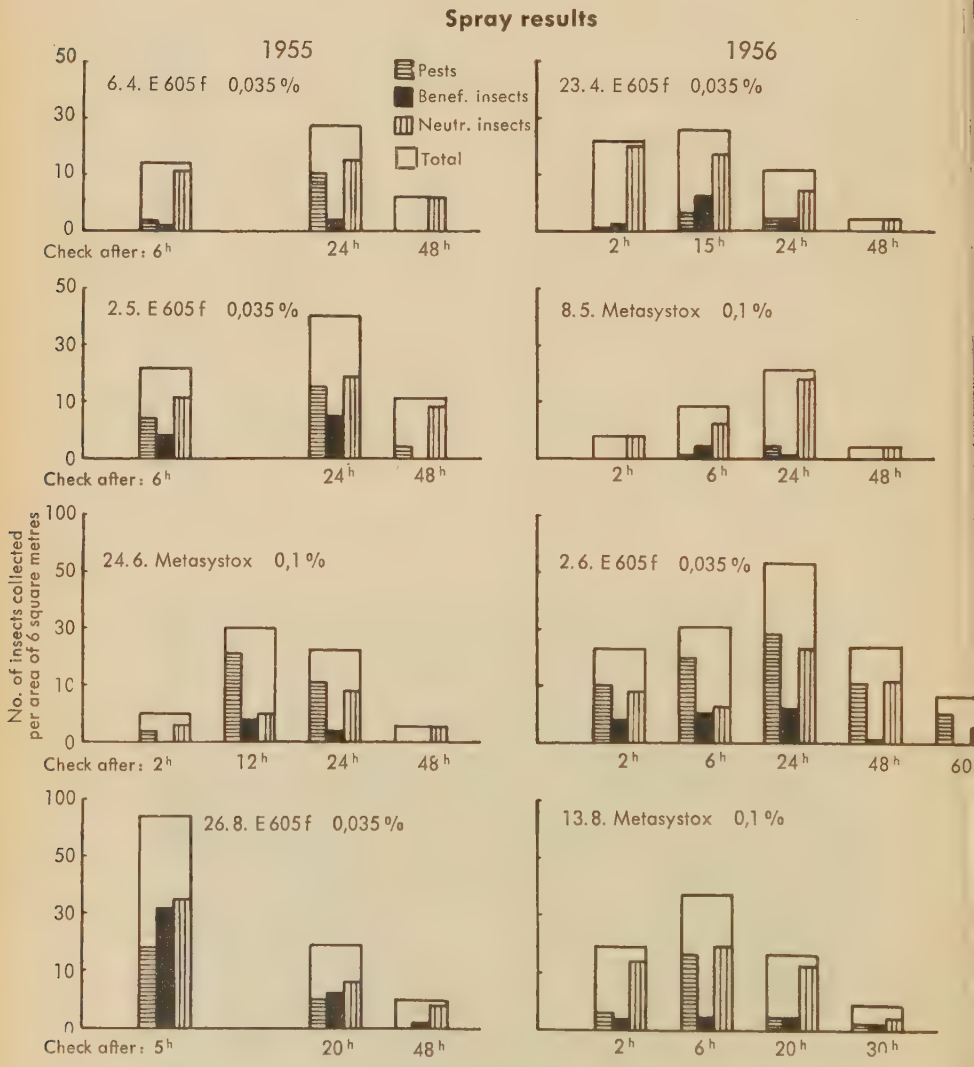

Spray results
1955
1956
Pests
Benef. insects
Neutr. insects
Total
6.4. E 605 f 0,035 %
23.4. E 605 f 0,035 %
2.5. E 605 f 0,035 %
8.5. Metasystox 0,1 %
24.6. Metasystox 0,1 %
2.6. E 605 f 0,035 %
26.8. E 605 f 0,035 %
13.8. Metasystox 0,1 %
No. of insects collected per area of 6 square metres
Check after: 6h 24h 48h
Check after: 2h 15h 24h 48h
Check after: 6h 24h 48h
Check after: 2h 6h 24h 48h
Check after: 2h 12h 24h 48h
Check after: 2h 6h 24h 48h 60
Check after: 5h 20h 48h
Check after: 2h 6h 20h 30h

Fig. 29: Mortality of insects and *Arachnoida* registered after spray applications in 1955 and 1956. (Pests, beneficial insects and neutral insects are entered separately). (Ordinate: No. of insects collected per area of 6 sq. m. [N = 30]. Abscissa: Intervals between checks in hours.)

The dead and moribund insects that fell onto the sheets (total area of 30 sq. metres) were collected at certain intervals, and identified; those insects still living were kept under further observation in the laboratory.

The results of the test are plotted in Fig. 29. Pests, beneficial insects and neutral insects are entered separately. (In this evaluation, no consideration was given to *Aphidae, Psyllidae, Micro-Diptera* and *Acarida).*

The average numbers of insects collected in an area of 6 square metres are entered on the ordinate, and the intervals between the checks are entered in hours on the abscissa.

It was observed that the majority of the insects fell to the ground 12 to 24 hours after application of the two products. Only a few insects were found on the sheets after 48 hours.

The differences in the total mortality figures recorded during the vegetation period are due firstly to the varying seasonal composition of the tree top fauna (see Section C, II, P. 188), and secondly to the varying action of the two insecticides that were applied. FOLIDOL-E 605 forte was most effective against pests all through the vegetation season, and in addition proved to be highly toxic to predators and neutral insects. METASYSTOX, on the other hand, was found to be much less harmful to beneficial insects. The fact that the influence of the insecticides on beneficial insects became greater as the vegetation season progressed — this applies just as equally to METASYSTOX as it does to FOLIDOL-E 605 — can be explained by the shift in the population density from mid-July onwards in favour of the beneficial insects (see also Figs. 7 and 8).

Similar results were obtained in a test also carried out at the Höfchen Research Centre on standard apple trees which had not previously been treated with chemical pesticides.

Twenty equivalent trees were selected for this test, and were sprayed on August 16, 1956 with the following Bayer products:

1.	FOLIDOL-E 605	0·035 %
2.	METASYSTOX	0·1 %
3.	ERADEX®	0·2 %
4.	DIPTEREX®	0·1 %

Four trees were sprayed with water as controls, in order to establish to what extent the insects are simply washed off the trees.

The results of the test are plotted in Fig. 30.

The majority of the killed insects were found after 16 hours. A further fall of insects (mainly ants) after 48 hours may be attributed to heavy rainfall at the time.

E. Studies on the influence of cultural practices on yield and growth of fruit trees

The results given in this section attach importance only as values for general orientation. Unfortunately there were too few equivalent trees at the site for an exact evaluation of the test to be carried out, added to which no values were on record for previous years.

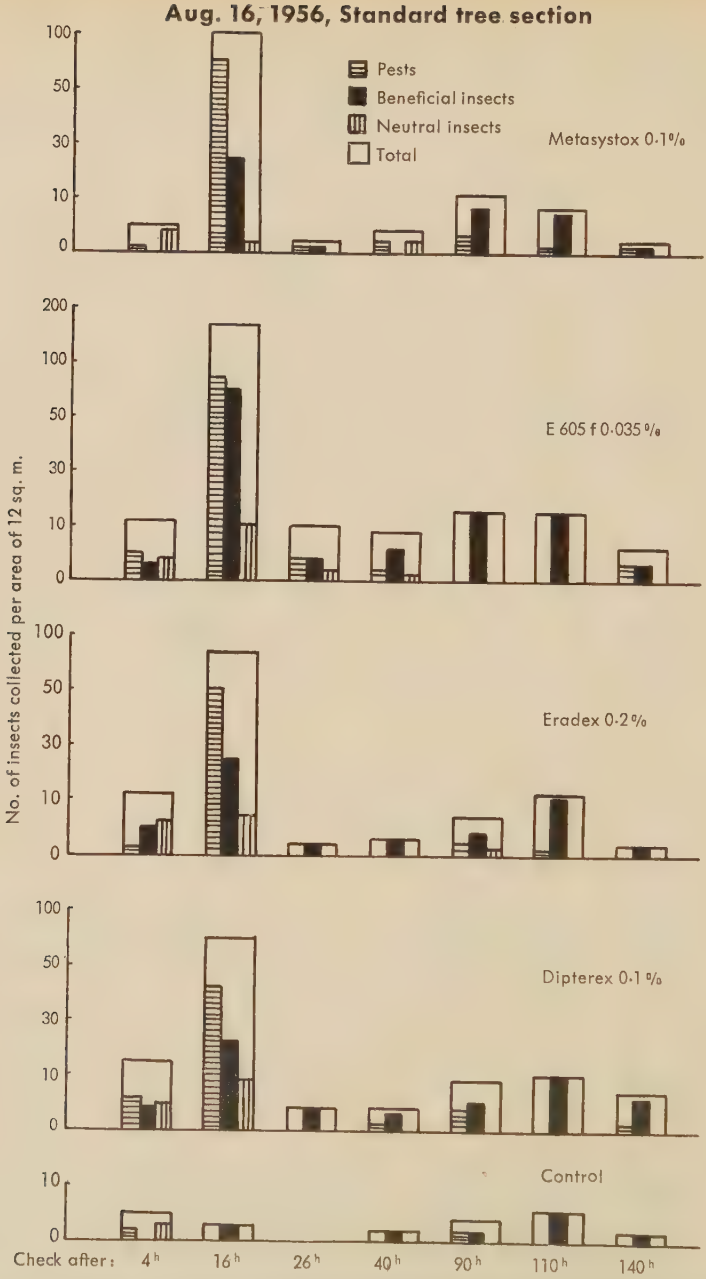


Fig. 30: Mortality of insects and *Arachnoida* registered after spray applications in August, 1956. (Ordinate: No. of insects collected per area of 12 sq. m. Abscissa: Intervals between checks in hours)

The test trees were planted in 1941 and were all treated in the same manner — pruning, fertilization, pest control — until 1951. From this year onwards, some of the trees (U-plot) were not sprayed and in fact not pruned from the winter of 1955/56 onwards. The other trees (B-plot) were sprayed and pruned regularly from 1952 onwards (but not sprayed in 1951, either).

Soil cultivation and fertilization were continued in both test plots also after 1950.

In order to determine the influence of cultural practices on the yield of the fruit trees in these test plots, the average yields of 108 apple trees were calculated for the period from 1948 to 1956, and the results for the two plots were then compared (Fig. 31).

It is noticed from the graph that the yields obtained in the B-plot hardly differ from those of the U-plot until 1950. From 1951 onwards, however, the treated plot yields are well above those recorded for the untreated plot. The constantly growing yield increases registered in the B-plot from 1952 onwards (see also Table 28) were undoubtedly due to the pest control operations regularly carried out in this plot after 1952.

It is, however, noticeable that the difference in the yields of the two plots was already most considerable in 1951, at a time when both plots were given the same treatment (pruning and fertilization, but no pest control). This may be accounted for simply by the fact that the B-plot was less exposed to

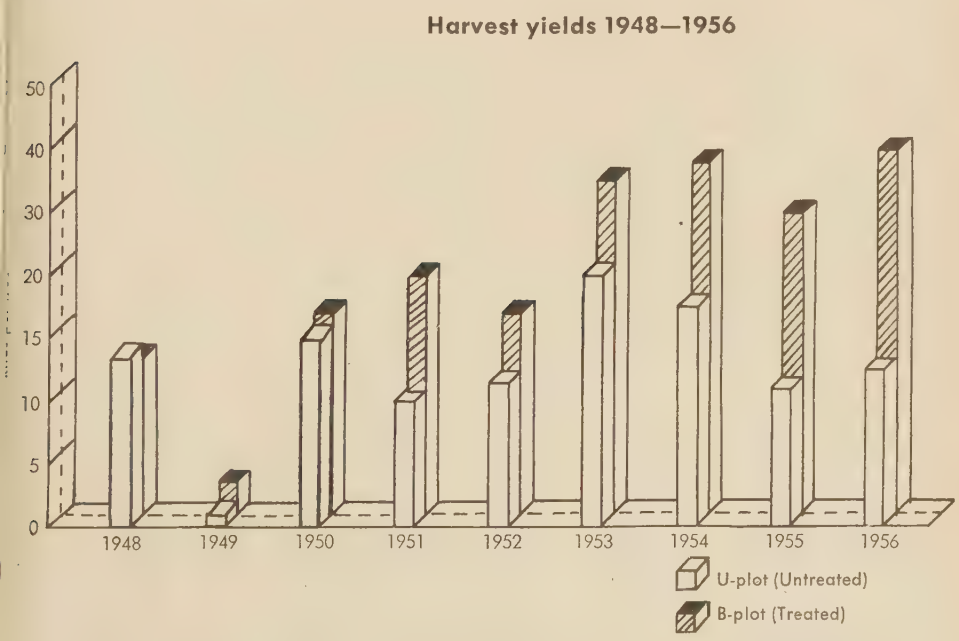


Fig. 31: Average yields on an apple tree in the treated and untreated plots, 1948—1956 (N = 108) (Ordinate: Weight in kilos)

weather influences than the U-plot, although the termination of winter spraying in the preceding year and the severe winter moth infestation in spring, 1951 may also have had a certain bearing on this.

Table 28: Average yields of an apple tree in the treated and untreated plots, 1952—1956 (N = 108).

	Weight in kilos		Relative yield increase
	untreated	treated	untreated = 100
1952	11	16	145·5
1953	21	32	152·5
1954	17	36	212·0
1955	11	28	245·5
1956	12	38	316·5

The yields of several apple varieties are plotted in Fig. 32 for the same years. Once again, the curves for the treated and untreated plots differ considerably from 1952 onwards. A noticeable feature is the more or less regular alternation of years of harvest yields and crop failure in the two test plots.

The results in Table 29 indicate the extent to which cultural practices may also influence the size and weight of fruit.

The values listed in Table 29 are based on measurements and weighings of 100 fruits of each variety.

Table 29: Measurements of fruit size and weight, 1956 / N = 100.

	Average fruit size in mm		Average fruit weight in g	
	treated	untreated	treated	untreated
Cox Orange	57·0	50·5	91	64
Zuccalmaglio	55·9	49·0	77	59
Oldenburg	55·3	45·7	62	52
Jonathan	57·6	51·6	86	60

Table 30: Tree dimensions, 1956 (N = 108).

Variety and parent stock	Average tree height in metres		Average crown breadth in metres		Average trunk dia. in cm	
	treated	untreated	treated	untreated	treated	untreated
Jonathan II	5·0	4·5	4·0	3·5	47	42
Cox Orange II	5·0	4·5	4·5	4·0	59	49
Cox Orange IX	4·0	3·5	3·5	3·0	33	24
Oldenburg I	6·0	5·5	5·5	5·0	64	58
Oldenburg IX	4·0	2·5	3·0	2·0	28	22
Zuccalmaglio II	5·0	4·5	4·0	4·0	53	52
Zuccalmaglio IV	4·5	4·5	4·0	3·5	43	41
Ellisons IX	4·5	4·0	4·0	3·0	34	30

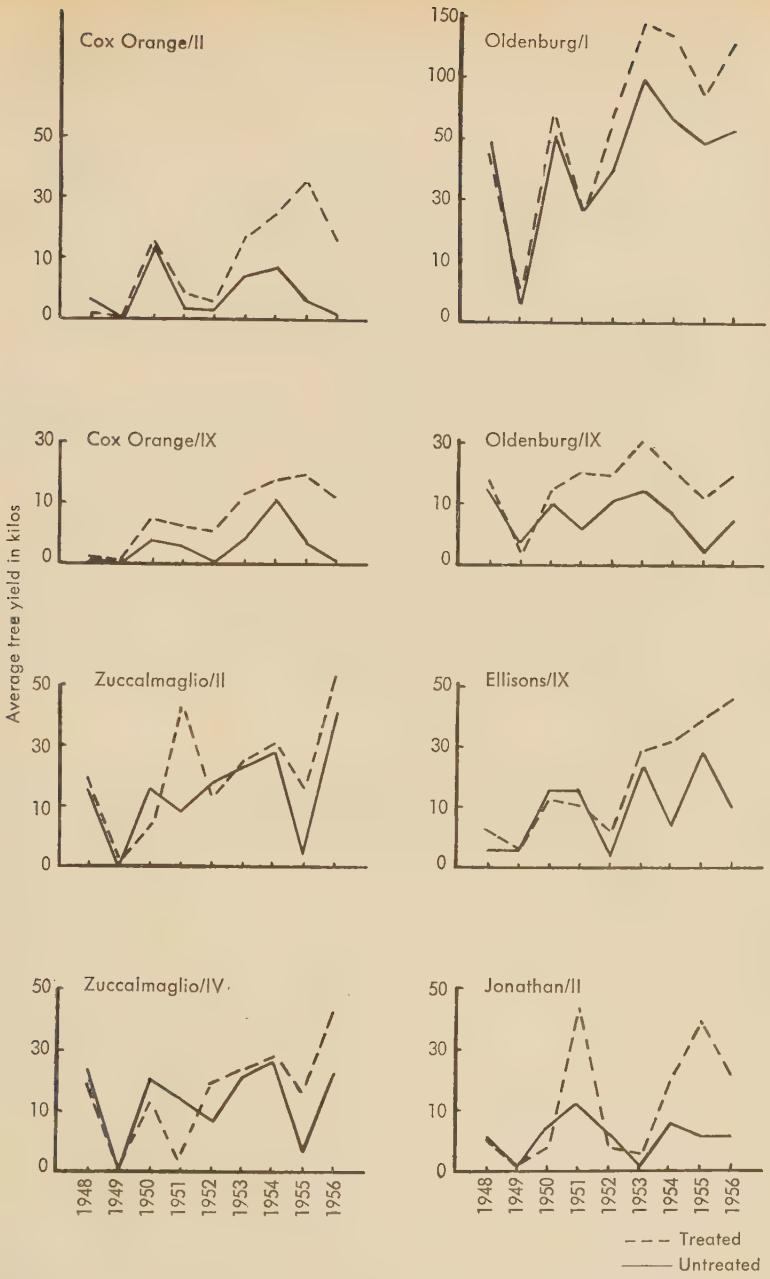


Fig. 32: Harvest results for the different apple varieties in the B- and U-plots, 1948-1956. (Ordinate: Average tree yield in kilos [N = 12] Abscissa: Year)

A marked difference between the treated and the untreated plot is also reflected in the tree dimensions, as shown in Table 30. Unfortunately there were no corresponding values on record for previous years. Only the age of the test trees is known. They were all planted in 1941.

F. Discussion

A critical study of the trap methods employed to register the fruit tree fauna in treated and untreated plots permits the conclusion to be drawn that at least good relative values can be obtained by means of such methods. Bud, green cluster and leaf counts plus branch controls also provide absolute quantitative data with respective to the numbers of insects that are trapped. It is important that the test methods are carried out in exactly the same manner in all plots. Any possible test errors that are not accurately recorded thus equally apply to all plots.

The values obtained by means of the bait trap method are the only ones for which limitation must be exercised when drawing comparisons because the bait liquid is capable of exerting a luring effect of unknown magnitude beyond the area of the plots being compared.

Registration of the fruit tree fauna in treated and untreated plots reveals, as the first outstanding result of such an undertaking, that a relatively large abundance of species, both pests as well as beneficial and neutral insects, may be registered also in the treated plot. Therefore, an artificial "Lebensraum" by no means has to be necessarily regarded as being poor in species. But as one would well expect, the population density of most species is far smaller in treated plots than in untreated plots. The population density is simultaneously linked — a factor of special importance to the economic assessment — with a yield increase and growth stimulation.

The results of the studies also show that the different species of pests and predators are not equally affected by control operations. Caterpillars, *Psyllidae*, *Coccidae* and predaceous *Acarida* are severely decimated, *Coleoptera*, *Heteroptera*, *Neuroptera* and *Syrphidae* are moderately decimated, while *Dermaptera* and *Opilionidae* are either not decimated at all or if so then only to a very slight degree. *Aphidae* and *Tetranychidae* in fact occur on an increased scale after applications of pesticides. What are the reasons for this varying degree of influence exerted upon the different insect groups? In answering this question, special attention must be given to the two groups of pests mentioned last in the above list, namely aphids and spider mites, and to their considerably increased occurrence in late summer. This is necessary for aphids and spider mites not so much because any economic setbacks resulting from such increased occurrence need be feared in the current vegetation year but because a severe infestation must be anticipated from the very outset in the following year.

The species-specificity may be regarded as an essential reason for the varying degree of influence upon the different insect groups. It is after all a generally known fact that each species reacts specifically to the influences of certain factors. Separate studies would have to be conducted to establish how each of the species in question, especially the predators and neutral insects, react to the applied products. It is known how most species of pests react since this is a matter involving questions which must be answered in order

for a product to be accepted and recommended. The polytoxicity of FOLIDOL-E 605 does not preclude a species-specificity but it offers only few species the possibility of evasion. The situation is quite different with the oligotoxic product METASYSTOX. This insecticide especially acts against aphids and spider mites and temporarily causes an almost complete eradication of these very species so that it is all the more incomprehensible why such an increased number of eggs is laid in the treated plot in late autumn. Therefore, differences in species-specific reaction can hardly be of any bearing in the case of these two species.

A further reason for the varying degree of influence exerted upon the different insect groups is the multiplication potential (number of generations). When spider mites and aphids, for example, are compared with the other groups in question, it is found that they differ from most of them by virtue of their high rate of multiplication. Only few species that survive a control operation are capable of building up a new and large population within a short time, provided of course the environmental conditions are favourable to this. — Furthermore, it is just these environmental conditions and also the local mobility of the insects that are of such great importance. — Without doubt, the conditions for the development of aphids and spider mites on cultivated trees are far more favourable than on trees that are not given careful treatment, for the simple reason that the healthier foliage, which is present for a much longer time, provides better feeding conditions, and thus fulfills an important prerequisite for mass infestation. — Both aphids and spider mites, by virtue of their ability to fly and the fact that they are easily carried by the wind, are permanently in abundance, so that the necessary insect material for a renewed initial infestation is constantly available in this case.

It may, therefore, be said that favourable development conditions prevailing over a lengthy period in combination with a high multiplication potential and constant "new infestations", can be regarded as the principal causes for the large population densities of aphids and spider mites in a treated plot after the close of control operations.

Added to these causes is the merely slight occurrence of natural enemies which, with the exception of the parasitic *Hymenoptera*, all have a lower multiplication potential, and are unable to keep pace with increases in the numbers of pests. The extent to which the decimated predator fauna is partly responsible for the increased, late season infestation of aphids and spider mites and the laying of larger numbers of winter eggs by these pest species, constitutes a question that would have to be investigated in separate studies.

Apart from such factors as the differences in species-specific reaction, multiplication potential, behaviour (concealed and nocturnal habits), and active and passive distribution, the stage of development of the insects at the time the applied poisons are brought to act upon them is also a factor that has bearing upon the varying degree of influence exerted by control operations upon the different faunal groups. It is of course well known that the various stages of development of one and the same species often greatly differ in their susceptibility to the applied poison. For example, the results of these studies show that the larval stages of most of the registered noxious and beneficial insects occurring on the fruit tree — such as *Geometridae, Tortricidae, Noc-*

tuidae, Coccinellidae, Chrysopidae, Hemerobiidae, Syrphidae etc. — were more severely harmed by the insecticides than the imagines.

The existence of these stage-specific differences provides in theory at least one possibility of minimizing the secondary effects on the predator fauna by carrying out precisely timed spray applications. The question as to whether and to what extent this can be realised in practice, depends in turn upon whether such timing, carefully calculated to preserve the beneficial insects, can be made to correspond with the optimum control date.

A question also of decisive importance is whether a shift is brought about in the numerical ratio of pests, beneficial insects and neutral insects in the treated plot and the unsprayed plot. These studies however, do not permit any conclusions to be drawn in this direction. The values obtained by means of the different methods cannot be applied to the desired unit, namely a fruit tree or a plot. Methodically, it would be necessary to use a certain number of leaves or green clusters, on the one hand, and trap areas, bait jars, yellow pans or trap bands, on the other hand, as the unit for the catches. However, these cannot be applied by computation to a single tree or a given number of trees. Thus, the possibility is eliminated of calculating the numerical ratios between beneficial and neutral insects on the one side and pests on the other side. Most values which are given as the occasion offers, in actual fact contain no proof of any conclusiveness. Furthermore, beneficial insects registered by one particular method are not solely enemies of the pests registered by the same method.

A most noteworthy finding is that the pests are more abundant than the predators at the beginning of the vegetation season, in other words at a time which is especially critical for the vegetative and generative development of the fruit tree. Such a situation automatically forces one to make greater use of pesticides in the first months of the vegetation period. During the course of the year, the ratio of pest to predator shifts on the aggregate in favour of the predator, when one disregards aphids and spider mites, and makes allowance for the absence of fruit pests in Höfchen.

These studies primarily apply to the orchard at Höfchen under the conditions prevailing there. It cannot be said, however, to what extent they can be applied to other plantations, especially in areas where there is a different climate. In applying the results of these plot tests to complete plantations, allowance would have to be made for the environmental influence, the marginal and adjacent effect and the influences on recolonization.

In the test plot, no cases of "total eradication" were established for any faunal group, except for *Coccidae, Psyllidae* and *Carpocapsa* which were lacking in the plot from the start of the test onwards; a recolonization of the plot by the different pests and beneficial insects was observed to have begun at the latest four weeks after the application of pesticides, although usually within two weeks.

G. Summary

The object of these studies was to widen the knowledge of the pest and predator fauna of orchards, and to obtain more information on the changes brought about in this fauna when it is exposed to the influence of chemical controls. For this purpose, the fauna of large treated and untreated plots at the Höfchen Research Centre, was carefully registered by means of various trap

methods including the tree jarring trap method, the yellow pan trap method and bait jar trap method (employed throughout the year), branch, leaf, bud and green cluster counts, corrugated paper band and sticky band methods (carried out only at the most suitable times of the year for such practices).

A comparison of the treated plot with the unsprayed plot produced the following results:

1. Little or no differences existed between the two plots with respect to the composition of their fauna.
2. The population density of most species was constantly much smaller in the treated plot than in the unsprayed plot.
3. Only *Coccidae* were completely eliminated.
4. Equal or higher infestation figures than those recorded in the "untreated" plot were registered in the treated plot for *Neuroptera* (adults), *Dermaptera* and *Opilionidae*.
5. Despite far-reaching eradication of existing populations by the spray applications, *Aphidae* and *Tetranychidae* reacted in autumn by intensifying their occurrence and laying increased numbers of winter eggs in the treated plot on a scale much greater than that recorded for the untreated plot.
6. The controls brought about an almost complete elimination of numerous faunal groups each time they were carried out in the treated plot, yet nevertheless the plot was recolonized within a few weeks after the spray applications.
7. The crop yields obtained in the treated plot were bigger and of better quality than in the untreated plot.

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